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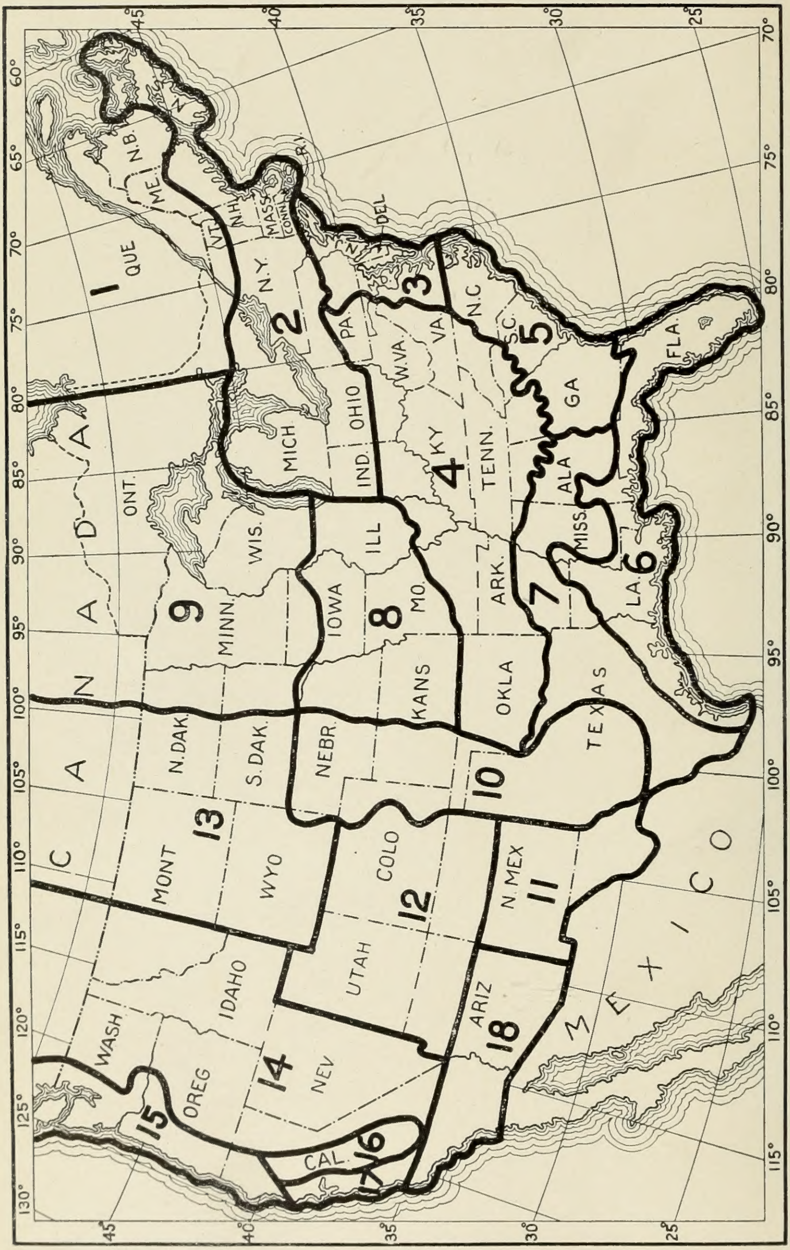
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MAP SHOWING THE POMOLOGICAL DISTRICTS OF THE UNITED STATES AND CANADA.

in Industry, Soils and Agricultural Engineerin

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 151.—160

B. T. GALLOWAY, *Chief of Bureau.*

FRUITS RECOMMENDED BY THE AMERICAN POMOLOGICAL SOCIETY FOR CULTIVATION IN THE VARIOUS SECTIONS OF THE UNITED STATES AND CANADA.

REVISED BY
A COMMITTEE OF THE AMERICAN POMOLOGICAL SOCIETY,
W. H. RAGAN, CHAIRMAN.

ISSUED JUNE 26, 1909.— Oct 1909

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BUREAU OF PLANT INDUSTRY.

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POMOLOGICAL COLLECTIONS.

G. B. Brackett, *Pomologist.*
W. H. Ragan, *Expert in Pomological Nomenclature.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., February 26, 1909.

Sir: I have the honor to transmit herewith a manuscript entitled "Fruits Recommended by the American Pomological Society for Cultivation in the Various Sections of the United States and Canada." This catalogue has been prepared by the committee of the American Pomological Society on revision of the catalogue of fruits, of which Prof. W. H. Ragan, Expert in Pomological Nomenclature, Bureau of Plant Industry, is chairman, and has been submitted for publication by Col. G. B. Brackett, Pomologist.

The varieties of fruits included in these pages have been recommended and rated by practical growers, who have tested them in various sections of the country, and these lists can not fail to prove of value to the planter who wishes reliable information as to what fruits will probably succeed in his soil and locality.

This manuscript constitutes the third revised catalogue of fruits which has been prepared under the joint auspices of the United States Department of Agriculture and the American Pomological Society, the others having been published as bulletins 6 and 8 of the Division of Pomology, which became a part of the Bureau of Plant Industry upon its organization in 1901. The bulletins mentioned have proved of great value and several editions have been required to meet the large demand for them.

I recommend that this manuscript be published as Bulletin No. 151 of the special series of this Bureau.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFATORY STATEMENT.[a]

The revised catalogue of fruits recommended for cultivation in the various sections of the United States and Canada, prepared under the joint auspices of the American Pomological Society and the Bureau of Plant Industry of the United States Department of Agriculture, is herewith submitted.

In making this revision the chairman of the committee has availed himself of all the practical information that could be secured concerning the behavior of varieties in the several districts into which the territory covered has been subdivided. Heretofore lists of this character have been made up largely upon the recommendation of a comparatively few experts, while the masses of practical fruit growers have been less freely consulted. In this case the expert has not been ignored, but his testimony has been strengthened by that of a large number of less known, though nevertheless worthy, fruit growers, whose locations and practical experience entitle their opinions to favorable consideration. These were reached and consulted through a series of inquiries sent out from this Office. About two thousand of these inquiries were mailed, and they brought many satisfactory answers, which, being compiled by districts, form the basis of the subjoined fruit lists; but with all this painstaking we are well aware of the fact that infallible fruit lists have never been produced. So variable are conditions that a variety which proves satisfactory in one season or in one neighborhood may prove the reverse near by or even another year with the same grower. These facts render hasty conclusions unsafe and should admonish the planter to cultivate patience in deciding upon varieties.

It will be found, also, that honest differences may exist in regard to qualities that combine in the formation of estimates we place upon a given variety. Mere excellence of the fruit itself may be the basis of one man's ratings; another may consider its commercial value as its highest quality, while yet another will carefully consider a combination of qualities, such as hardiness of tree or plant, its fruitfulness under varying conditions, etc., yet the rating of each must be given as identical in lists like these.

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[a] It should be borne in mind that these lists are not merely the reflections of opinions having their origin with the chairman and his colleagues in the offices of the Bureau of Plant Industry, but are the deliberate ratings of practical fruit growers in the several pomological districts, obtained through extensive correspondence, each speaking for himself and from his own standpoint of experience with the variety under consideration. The correspondence referred to was conducted during the first half of the year 1908, and this compilation of results is therefore as nearly up to date as possible.

The general plan of this catalogue is that of its predecessors that were evolved during many years of intelligent, patient labor by men like Wilder, Downing, Thomas, Barry, and Lyon, to whom we owe debts of gratitude. In consequence of the growth and development of our country, as well as of the greater number of varieties now cultivated and the rapidly expanding industry of fruit growing, a steadily increasing list of varieties forces itself upon us. What are therefore really select lists of fruits become apparently lengthy, but in fact are not, since the varieties embraced in this catalogue actually constitute eighteen separate lists. It will be seen, however, that many varieties are only recommended "for further trial," thus indicating that they should be planted with proper caution.

As heretofore, Prof. E. J. Wickson, of the University of California, has had much to do with the preparation of the lists for the Pacific Coast States, though a large number of individual fruit growers living within that territory have been freely consulted.

Respectfully submitted:

W. H. Ragan, *Chairman.*

Office of Pomological Collections,
Washington, D. C., February 19, 1909.

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B. P. I.—458.

FRUITS RECOMMENDED BY THE AMERICAN POMOLOGICAL SOCIETY FOR CULTIVATION IN THE VARIOUS SECTIONS OF THE UNITED STATES AND CANADA.

PLAN OF THE CATALOGUE.

This catalogue embraces species and varieties of fruits and nuts recommended for cultivation in the United States and the British North American provinces. These are arranged alphabetically in two[a] divisions, as follows:

Division 1.—Species and varieties mainly adapted to culture in the Northern and Middle States of the United States and in adjacent portions of the British provinces.

Division 2.—More southern, tropical, and subtropical species and varieties.

Varieties known to succeed in a given district are indicated by an asterisk (*); if highly successful, by two asterisks (**); if considered promising, by a dagger (†); and if not reported on, by a dotted line (   ). These conclusions are not, however, to be accepted as absolutely correct and infallible, but rather as reflections of the opinions and experiences of practical fruit growers within the district. On account of the extended range of the districts and of the varying soil and climatic conditions that prevail within them, the above caution must be kept in mind in considering the recommendations made in this catalogue. No planter should attempt to follow its markings absolutely, but should rely rather largely upon the experience of others within his immediate vicinity and a correct knowledge of his own location and environment in the district.

Following the rules and recommendations of the American Pomological Society,[b] prefixes, suffixes, secondary words, and apostrophic or possessive terminations, together with words whose significations are expressed in the descriptive columns, are eliminated from the names of varieties when not required to insure their identity. Synonyms are italicized and included within parentheses.[a] Foreign names of varieties are only anglicized in the interest of brevity or for convenience of pronunciation.

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[a] The third division of the lists previously printed is omitted from this publication because of the lack of agreement among botanists as to the proper classifications of the different species.

[b] See p. 65.

The entire territory represented is divided into eighteen pomological districts, with little regard to State or provincial boundaries, but with primary reference to the influence of latitude, elevation, prevailing winds, and oceanic and lacustrine exposures upon their adaptation to pomological pursuits (see map, Pl. I).

POMOLOGICAL DISTRICTS AS DEFINED BY THE AMERICAN POMOLOGICAL SOCIETY.

District No. 1.—Maine above 500 feet elevation; New Hampshire, Vermont, and New York north of latitude 44°; Ontario north of Lake Simcoe and east of longitude 80°; Quebec, New Brunswick, and Prince Edward Island. The dominant natural feature of this district is the St. Lawrence Valley. Many of the hardier fruits flourish within its borders.

District No. 2.—Nova Scotia; Maine below 500 feet elevation; New Hampshire and Vermont south of latitude 44°; Massachusetts; Rhode Island; Connecticut; New York south of latitude 44°, except Long Island; northern New Jersey above 500 feet elevation; Pennsylvania east of the Susquehanna River and above 500 feet elevation, north of latitude 41° west to the Allegheny River, and all of that portion of the State lying north of the Ohio River; Ohio and Indiana north of latitude 40°; the lower peninsula of Michigan; and Ontario south of Lake Simcoe. The Annapolis Valley of Nova Scotia, the North Atlantic coast, the lake region of western New York, Ohio, Ontario, and Michigan, and the Hudson River Valley are the leading features of District No. 2. This may be considered the northern grape, peach, and winter-apple district.

District No. 3.—Long Island; New Jersey, except a small portion north; eastern Pennsylvania below 500 feet elevation; Delaware; and Maryland and Virginia below 500 feet elevation. This is the Delaware and Chesapeake Bay district. Though a small district, its productive capacity of the fruits that succeed within its borders is great.

District No. 4.—Pennsylvania above 500 feet elevation and south of latitude 41°; Maryland, Virginia, North Carolina, South Carolina, Georgia, Mississippi, and Alabama above 500 feet elevation; West Virginia; Tennessee and Kentucky; Ohio and Indiana south of latitude 40°; southern Illinois below the general elevation of 500 feet, from the Wabash to the Mississippi; Missouri south of a line from near St. Louis and along the elevation of 1,000 feet to the southeast corner of Kansas;

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[a] Synonyms are used for the better identification of varieties.

Oklahoma below 2,000 feet elevation; and Arkansas north of latitude 35°, also south of it wherever the elevation exceeds 500 feet. The Allegheny and the Ozark mountains and the valleys of the Ohio, the Tennessee, and the Cumberland, and portions of the Wabash, the Mississippi, and the Arkansas rivers are embraced within this district. Portions of it are noted fruit regions, while throughout its vast territory the hardier deciduous fruits flourish. Many of the varieties recommended succeed best in certain localities within the district. An exception to the general character of the district occurs in those portions of Kentucky, Tennessee, Arkansas, and southeastern Missouri lying near the Mississippi River, where varieties adapted to culture in districts 5 and 7 generally succeed.

District No. 5.—Eastern North Carolina, South Carolina, and Georgia below 500 feet elevation; and Florida north of latitude 30° east of the Chattahoochee River and above 100 feet elevation. This district embraces the southern Atlantic seaboard, with its many frith-like indentations and valleys. The climate is generally mild, and within its borders many of the more tender deciduous fruits flourish.

District No. 6.—Florida south of latitude 30°, the remaining portions of the State with elevations below 100 feet, and those portions of Alabama, Mississippi, Louisiana, Arkansas, and Texas lying below the 100-foot contour line as it skirts the coast from Florida to the Rio Grande. This is the southern peninsula and the Gulf Coast district. The successful culture of citrus and other subtropical fruits and nuts is restricted to the peninsula portion of Florida and to the Delta of the Mississippi. Tropical species are only recommended for that portion of Florida lying south of latitude 27°, and are indicated by the letter *s* in connection with the starring.

District No. 7.—Florida west of the Chattahoochee River and above 100 feet elevation; Alabama, Mississippi, Louisiana, and Arkansas above 100 and below 500 feet elevation; and Texas south of Red River and above 100 and below 1,000 feet elevation. This may be denominated the valley district. It embraces portions of the Chattahoochee, Alabama, Pearl, Mississippi, Arkansas, Red, Sabine, Colorado, and Rio Grande valleys. The climate in the eastern and larger portion is warm and moist, in the extreme west more dry and tending toward aridity. A wide range of the more tender varieties and species is adapted to culture in the district.

District No. 8.—Illinois north of the 500-foot contour line as it crosses the State between 38° and 39° latitude; a very small portion of southwest Wisconsin; Iowa south of about latitude 42° 30′; the Missouri River Valley portion of southeastern South Dakota; Nebraska and Kansas below 2,000 feet elevation; and Missouri north of a line drawn from near St. Louis and along the elevation of 1,000 feet to the southeast corner of Kansas. The Missouri and Mississippi valley sections of the district are its dominant features. The hardy deciduous fruits succeed in most portions, and commercial fruit growing is a rapidly developing industry.

District No. 9.—Wisconsin except the small southwest corner; Minnesota; upper Michigan; Iowa north of about latitude 42° 30′; North and South Dakota east of longitude 99°; and Canada west of longitude 80° and east of longitude 99°. This district embraces the upper lakes, including Winnipeg, the upper Mississippi and the Red River valleys. Only the hardier fruits succeed, but fair progress has been made in recent years in developing varieties adapted to this region.

District No. 10.—Nebraska, Kansas, and Oklahoma above 2,000 feet, and Colorado below 5,000 feet elevation; also Texas above 1,000 feet and east of longitude 103° and the Pecos River. This is the central plain and foothill district. It lies on the eastern slope of the Continental Divide. There are small sections, especially in eastern Colorado and farther southward, where the apple and other hardy fruits are successfully grown.

District No. 11.—Texas west of longitude 103° and the Pecos River, and New Mexico south of latitude 35°. The Pecos and Rio Grande valleys are the characteristic features of this district. Considerable effort at growing fruit, especially of apples and the hardier vinifera grapes, is being made in many localities.

District No. 12.—New Mexico and Arizona north of latitude 35°; Utah; and Colorado above 5,000 feet elevation. This district embraces the Continental Divide and the Great Salt Lake, and it also embraces the valley and canyon of the Colorado and the sources of the important streams south of the Missouri and Yellowstone. It affords a great diversity of soils and climatic conditions, and hence a wide range of fruit growing. The species successfully grown within the boundaries of this district range from the vinifera grapes to the hardy ironclad apples.

District No. 13.—The Dakotas west of longitude 99°; Wyoming; Montana east of longitude 111°; and the British provinces lying between longitude 99° and 111°. The upper Missouri and Yellowstone valleys are the distinctive features of the district. There is perhaps no section of the district in which fruit growing has reached a very high state of development. Leading causes of this condition may be found in the comparatively undeveloped or unsettled state of the country and its great elevation.

District No. 14.—British America west of longitude 111° and east of longitude 122°; Montana west of longitude 111°; Idaho; Nevada; and Washington, Oregon, and California east of the general coast contour line of 1,000 feet elevation, commencing at the British boundary near longitude 122° and southward on said elevation to its intersection with the Southern Pacific Railway in the upper Willamette Valley, thence along the line of said railway to the Sacramento Valley, thence east and south on the eastern rim of said valley and that of the San Joaquin at an elevation of 1,000 feet to latitude 35°, thence east on said latitude to the Colorado River. The characteristic features of this district are the upper Columbia Valley and the Sierra Nevada Mountains. An exception to the general recommendation will appear in certain portions of Snake River Valley, where the vinifera grapes and other tender fruits succeed.[a]

District No. 15.—The coast section of British America west of longitude 122° and of Washington, Oregon, and California north of about latitude 39° 30′, and bounded on the east by districts 15 and 17. This district embraces the highly developed fruit-growing sections on Puget Sound and the lower Columbia and the Willamette rivers.[b]

District No. 16.—The Sacramento and San Joaquin valleys, bounded on the east by District No. 15 and on the west by the western rim of this great interior basin. The diversified fruit and nut products of this district are marvelous. There are localities in which the semitropical species and other places where the apple, pear, and other hardy fruits and nuts are grown to the highest perfection.[b]

District No. 17.—The coast section of California lying between latitude 35° and about 39° 30′ and bounded on the east by District No. 17. Its characteristic features are the Coast Range of mountains, the Russian River, and the Sonoma, the Santa Clara, and the Pajaro valleys.[b]

District No. 18.—California and Arizona south of latitude 35°. The dominant characteristics are the valleys of the Gila, the Colorado, the San Gabriel, and the Santa Ana, and the Sierra Madre Mountains. It includes the celebrated fruit districts of Santa Ana, Riverside, Santa Barbara, the Salt River Valley, San Diego, and many others.[b]

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[a] Recent developments of the fruit industry in several isolated localities in District No. 14 have demonstrated the fact that many of the deciduous fruits can be grown with perfect success. This is especially the case in the Hood River and Rogue River valleys in Oregon, in the Wenache and Yakima valleys in Washington, and in other favored sections.

[b] Districts 15, 16, 17, and 18 are peculiarly adapted to fruit and nut culture. Perhaps no portion of the earth's surface is more highly favored in climate and soil and affords a wider range of crop products than that lying within the boundaries of these four districts. The commercial value of the fruit and nut products of this section is recognized the world over.

FRUITS RECOMMENDED FOR CULTIVATION IN THE UNITED STATES AND CANADA.

Division I.—FRUITS MAINLY ADAPTED TO NORTHERN LOCALITIES.

This division includes such cultivated species, commonly designated "hardy" fruits and nuts, as have developed distinct varieties which are propagated on a commercial scale by some of the various methods of bud propagation.

Section 1.—APPLES (*Malus*).

[KEY.—Abbreviations used in the descriptions of varieties. *Origin:* Amer., America; Eur., Europe; For., Foreign; Fr., France; N. Y., New York; Ont., Ontario, etc. *Form:* c, conical; o, ovate; ob, oblate; obl, oblong; r, round. *Size:* l, large; m, medium; s, small; v, very. *Color:* b, blushed; c, crimson; d, dark; g, green; p, pale; r, red; ru, russet; s, striped; w, white; y, yellow. *Flavor:* a, acid; b, brisk; m, mild; p, pleasant; r, rich; s, sweet; sa, subacid; v, very; vi, vinous. *Quality:* b, best; g, good; p, poor; v, very. *Use:* c, cider; d, dessert; k, kitchen; m, market. *Season:* e, early; l, late; m, medium; v, very.]

SUBSECTION 1.—APPLES.

Name.	Description.								Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Flavor.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Akin (*Akin Red*)	Ill.	c	ml	yr	sa	vg	dm	l		†		†				*			*				**			
Alexander (*Emperor Alexander*)	Rus.	rc	vl	gyrs	a	g	km	m	**	**	*	*					†			†	**	**	*	*	*	
Allen Choice	Pa.	ob	m	yrs	a	g		l								*	*									
Anisim (*Anisimovka*)	Rus.	rc	m	yr	sa	g	dm	m								*	*									
Antonovka (*Anthony's Apple*)	Rus.	oblc	l		sa	p	m	m	*	*						*	*				†					
Arctic	N. Y.	rc	l	yr	sa	vg	km	l	*	*							†									
Arkansas (*Mammoth Black Twig*)	Ark.	oblc	l	yr	msa	vg	km	l		*	*	**			*	**		**	*	*		**	*	*		*
Arkansas Black	Ark.	rc	ml	dr		vg	km	l										*		*						
Arnold (*Arnold Beauty*)	Ont.	ob	m		sa	vg	d	vl		*																
Autumn Bough (*Autumn Sweet Bough*)	Amer.	rc	m	gy	s	vg	d	me		*		*				*										
Autumn Swaar (*Autumn Sweet Swaar*)	(?)	rob	m	y	s	g	k	m		*		*				*						*	*	*		
Bailey Sweet (*Patterson Sweet*)	N. Y.	roblc	l	yrs	vs	vg	dkm	m	*	**		*				**				*		*	*			
Baldwin (*Red Baldwin*)	Mass.	rc	ml	yrs	sa	vg	dkm	l	**	**	*	*						*		*	*	**	**	**	*	
Baltimore (*Baltimore Pippin*)	(?)	rc	m	gyrs	sa	vg	d	l									†					**	**			
Banana (*Winter Banana*)	Ind.	ob	m	yb	msa	vg	d	l				†								†						
Baxter (*Baxter's Red*)	Ont.	rc	vl	yrs	ma	g	m	l	†	†																
Beach (*Apple of Commerce*)	Ark.	rob	ml	gyrs	sa	g	dm	vl				*														
Belmont (*Gate, Waxen*)	Pa. ?	roblc	ml	y	msa	vg	d	ml		*		*											*			

Ben Davis (*Carolina, New York Pippin*)	(?)	roble	ml	yrs	sa	g	m	l	†	*	*	**			*	**	*	*	**	**	*	**	*	*	*	*
Benoni	Mass.	robe	ms	yrs	msa	vg	d	me		*	**	**				**	*	*		*						
Bentley (*Bentley Sweet*)	Va.?	rob	m	ygs	s	vg		l		*		*														
Bethel (*Bethel of Vermont*)	Vt.	r	ml	ys		vg	m	l	*	*												†				
Bietigheimer (*Red Bietigheimer*)	Ger.	obe	vl	wyrs	sa	g	km	me	*	*	*	*	*			*				*	†	*	*			*
Bismarck (*Prince Bismarck*)	For.	ob	vl	grs	ma	g	km	l				†				*						†	†		*	
Black (*Jersey Black*)	N.J.?	rob	m	dr	msa	g	dkm	ml		*		*														
Black Annette (*Black's Annette*)	Va.?	rob	m	dr		g		ml								*	†									
Black Gilliflower (*Red Gilliflower*)	(?)	oblc	m	dr	sa	g	km	ml		*																
Bledsoe (*Bledsoe's Favorite*)	Tex.	ob	l	grs		g	dm	me							*											
Blenheim (*Blenheim Orange*)	Eng.	rob	l	yru	sa	vg	dk	l	*	*						*										
Blue Pearmain	(?)	re	vl	drs	sa	vg	dm	l	**	*		*				*						*	*	*		
Bogdanoff	Rus.		l		sa	vg		l	†																	
Borken (*Boikenapfel*)	Rus.		ml			g		m	†	†																
Bonum (*Magnum Bonum*)	N.C.	ob	m	yres	msa	vg	d	ml			*	*	**													
Borovinka (*Mushroom*)	Rus.	re	ml		sa	g	km	me		*							**									
Bough (*Sweet Bough*)	Amer.	oble	ml	gy	s	vg	dk	e	†	**	*	**				*				*		*	*			
Bradford (*Kentucky Redstreak*)	Tenn.?	re	m	gyrs	sa	gvg	d	l			*	*				*	*									
Brewington (*Brewington Pippin*)	Ky.	robe	l	yrse	msa	vg		l								†										
Brilliant (*Brilliant* of Patten)	Iowa	r	l	yrb	msa	g		ml									†									
Broadwell (*Broadwell Sweet*)	Ohio	robe	ml	wyb	vs	vg	dk	m		*		*				*				†						
Brown (*Nottingham Brown*)	Md.?	ob	m	yrs	sa	vg	dm	m		*	*	*														
Buckingham (*Fall Queen, Byers' Red*)	Va.?	obe	ml	gyrs	sa	vg	dkm	ml		*	*	**	**		**	*		*		*						
Bullock (*American Golden Russet*)	Amer.	oble	ms	yru	sa	b	d	m		*		*								†						
Buncombe (*Red Winter Pearmain*)	South.	robe	ml	ywr	sa	gvg	dk	l		*	*	**	*			*				†		*	*		*	
Camak (*Camack's Sweet*)	N.C.	re	m	gyb	sa	g	k	l				*														
Canada Baldwin	Que.	ob	m		sa		dkm	vl	*																	
Canada Reinette (*Canada Pippin*)	Eur.?	obe	vl	gy	sa	vg	dm	l	*	*						†				†			*			
Cannon Pearmain (*Cannon*)	Va.?	re	m	yrs	sa	g	km	vl				*				*				†						
Carlough	N.J.	re		gyb	s	vg	dk	l				*														
Carter Blue (*Carter's Blue*)	Ala.	rob	l	grs	sa	vg		m			†	*	*		*											
Celestia	Ohio	re	l	gy	sa	vg	dk	m				†														
Champlain (*Sour Bough*)	Vt.?	robe	ml	gyb	sa	g	km	me		*	*	†				†										
Charlamoff	Rus.	rob	ml	rs		g		m		†						*	**				**					
Chenango (*Chenango Strawberry*)	N.Y.	oblc	m	wrs	sa	vg	dm	me		**	*	**				**				**						
Christmas (*Christ's Birth*)	Rus.																*									
Clayton	Ind.	robe	ml	gyrs	sa	gvg	dkm	l		*	†	*				*				†						
Clyde (*Clyde Beauty*)	N.Y.	re	l	grb	sa	g		ml		*																
Cogswell (*Cogswell Pearmain*)	Conn.	rob	ml	yrs	sa	vgb	dm	l		*																
Cole Quince (*Cole's Quince*)	Me.	rob	m	yb	sa	vg	k	m	*	*						*		*		*						
Collins (*Champion*)	Ark.	rob	ml	yrse		g	m	l				*			*	†						†				
Colorado (*Colorado Orange*)	Colo.	r	ml	yru	sa	vg		ml									†	*		*						
Colton (*Early Colton*)	(?)	re	m	gyr	sa	g	d	e			*	*				*										
Congress (*Congress Apple*)	Mass.	robe	lvl	yrs	sa	g		m		†																
Cooper Market (*Cooper's Market*)	Pa.	obe	m	yrse	sa	g	m	vl	*	*	*									*						
Cornell (*Cornell's Fancy*)	Pa.?	oble	m	yre	sa	vg	d	e	*	*	†	*				†										
[illegible]	Ohio	robe	l	gyr	sa	g	k	m				*				*										
Cranberry	Ga.	re	m	yrs		g				†																
[illegible]	Rus.	ob	ml		sa	vg		l									*									
Cullasaga (*Callasaga*)	N.C.	re	ml	yrse	sa	g		l				*			*											
Danvers (*Danvers' Sweet*)	Mass.	robl	m	gy	s	vg	dk	l		*		*				*				†						
Delicious	Iowa	oble	ml	yrs	ma	vg	dm	l				*			†	**	*	†		*		**	**			

Section 1.—Apples—Continued.

SUBSECTION 1.—APPLES—Continued.

Name.	Description.								Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Flavor.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Derby (*Derby Sockanfather*)	Vt.	ob	ml	yrs		vg	dm	l	*																	
Doctor (*Doctor Dewitt, Newby*)	Pa.	rob	m	yrs	sa	g	d	ml				†														
Domine (*American Nonpareil*)	(?)	ob	m	gyrs	sa	g	dkm	l	*	*	*	*				**	†			*						
Donneghan	Vt.	r	m		sa			m	*	*																
Dudley (*Dudley's Winter*)	Me.	r	ml	rs		g		l									*									
Dutch Mignonne	Hol.	robe	m	yrs	sa	gvg	km	l								†				†		*	*			
Dyer (*Pomme Royal*)	Fr.?	r	m	gyb	sa	vgb	d	m		*						*	*			†						
Early Cooper (*Cooper's Early*)	Amer.	rob	m	yb	sa	g		me				*				*		†		*						
Early Harvest (*Prince's Harvest*)	Amer.	rob	m	py	sa	vgb	dk	ve	*	*	**	**	**	*	*	*		*	*	**	*	*	**	**	*	*
Early Joe	N.Y.	obe	ms	yrs	sa	b	d	me		*	*	*				*										
Early Market									†																	
Early Pennock (*Shaker, Summer Pennock*)	(?)	rc	vl	yrs	sa	g	km	me		*	*	*			*	*				†						
Earlyripe (*Weidner*)	Pa.	rob	m	py	sa	g		me			*	*				*				†						
Early Scarlet	(?)				sa			e	†																	
Early Strawberry (*Red Juneating*)	N.Y.	rc	s	rs	sa	vg	dm	e	*	**	*	*				*										
English Russet (*Long-Limbed Russet*)	(?)	rc	m	gyru	sa	g	dm	vl	*	*	*	*			*	*				*			*			
Ensee	Ohio	rob	l	yrs	sa	vg	dkm	ml				†														
Esopus (*Esopus Spitzenberg*)	N.Y.	roble	l	yr	sa	vgb	dkm	ml		**		*								*		**	**	**	**	**
Evelyn	Minn.	r	l	wy	sa	gvg		l									†									
Evening Party	Pa.	ob	ms	yrs	sa	vgb	d	ml		*		*				†										
Fallawater (*Tulpehocken*)	Pa.	rc	vl	ygb	pmsa	g	km	ml	*	*	*	*	*			*				†						
Fall Cheese	Va.		l	grs	sa			ml				†														
Fall Harvey	Mass.	rob	l	py	psa	gvg	k	m	*	*																
Fall Jenneting (*Fall Geneting*)	Conn.	obe	l	gyb	bsa	g	m	m	*	*		*								*						
Fall Orange (*Holden Pippin*)	Mass.	r	l	pyb	sa	g	k	m		*	*	†				**	*									
Fall Pippin (*Pound Pippin*)	Amer.	roblob	vl	yg	psa	gvg	dkm	m	*	*	*	*				*		†		*		**	**	**	*	*
Fall Wine (*Fall Wine of the West*)	(?)	rob	ml	dr	msa	vgb	d	m		*	*	*				*				*		*	*	*		
Fameuse (*Snow, Snow Apple*)	Can.?	rob	ms	gyrc	sa	vgb	dkm	me	**	**		*				**	*			*		**	*			
Family (*McCloud's Family*)	Ga.	obe	m	yrs	sa	vg		me				*			*	*										
Fanny	Pa.	robe	l	drc	sa	vg		me		*	*	*				*				†						
Farrar (*Robinson's Superb*)	Va.		l					m				*			*											
Foundling (*Funtling*)	Mass.	robe	m	ygrs	sa	vg	d	me		*																
Fulton (*Stewart's Golden*)	Ill.	ob	m	yb	msa	gvg	d	ml				*				*				*						
Gano (*Black Ben?*) [either identical or very nearly so]	(?)	rob	l	dyr	msa	g	m	l		*	*	**			**	**	**	**		**	**	**	**		*	**
Garden Royal	Mass.	robe	ms	gysr	rsa	b	d	me		*						†										
Garfield	(?)	oble	l	grs	sa	vg	dkm	l								†	*									

Gideon	Minn.	rc	m	y	a	g	k	m	*	*		*				*	*			*	*					
Gilbert (*Gilbert's Seedling*)	Tenn.	rob	l	yrs	sa	vg	km	l				*					†									
Gilpin (*Carthouse, Little Romanite*)	Va.	robl	ms	yrs	rmsa	g	dmc	vl		*	*	*				*			*	†						
Golden Russet (N. Y.) (*English Golden Russet*)	Eng.?.	rob	m	gyru	a	gb	dkm	l	†	*		*				*	*			†			*			
Golden Sweet (*Orange Sweeting*)	Conn.	r	l	py	rs	gvg	km	me		**	*	**				**				*			*			
Golding (*American Golden Pippin*)	N. Y.?	robc	ml	y	brsa	vg	dm	ml		*		*				*				†						
Gravenstein (*Early Congress*)	Ger.	rob	l	yrs	sa	vg	km	m	*	*	*	*			*	*		*		*	*	*	**	**	**	**
Green Glass (*Glass Green*)	Rus.	oblc	m	yrs	a	p	km	me									*									
Grimes (*Grimes' Golden*)	W. Va	rob	m	y	rsa	vgb	dkm	ml	*	**	**	**	*			**	**	**		**		**	**	**		**
Grosvenor (*Lord Grosvenor*)	(?)															†										
Gully	Pa.		s	wb				e					*													
Haas (*Fall Queen, Gros Pomier*)	Mo.	obc	ml	gyrs	sa	gvg	km	m	*	*	*					*	*			*						
Hall (*Hall's Red*)	N. C.	obc	s	rc	visa	vg	d	l			†	*				†										
Hargrove	N. C.	rc	m	yb	bsa	gvg		ml					*		†											
Hawley (*Douse, Dowse*)	N. Y.	robc	l	y	rsa	vg		m	†							†										
Hibernal (*Orsimui*)	Rus.	ob	l	rs	sa		k		*	*						†	**				**					
Hightop Sweet (*Sweet June*)	Mass.	r	ms	py	vs	vg	dk	ve		*		*				*				†						
Hockett (*Hockett's Sweet*)	N. C.	rob	m	yrs	rs	g	km	l				*														
Holmes (Miss.)	Miss.														†											
Hoover (*Black Coal, Wattaugah*)	S. C.	rob	m	ydrs	rsa	vg		ml				*	*			*						*	*	*	*	*
Horn (*North Carolina Vandevere*)	Ga.	ob	ms	wyrs	sa	g		l				*														
Horse (*Yellow Horse*)	N. C.?.	robl	ml	yb	sa	g	km	me			*	**	*		**	*										
Hubbardston (*Hubbardston Nonsuch*)	Mass.	robl	l	yrs	sa	vg	dk	ml	*	**	*	*				*			*	*		*	*			
Hunge (*Hunger*)	N. C.?.	r	l	gb	sa	g	k	m				*														
Hunt Russet (*Golden Russet of Mass.*)	Mass.	robc	ms	yru	rsa	vgb	d	vl		*																
Huntsman (*Huntsman's Favorite*)	Mo.	obc	l	pyb	msa	vg		l				*				**		†		*						
Hyde King (*Hyde's King of the West*)	(?)		vl	yg		g		vl														*	*			
Ingram (*Ingram's Seedling*)	Mo.	robc	m	yrs	msa	vg	dkm	vl				**			*	**		†		*		*				
Indiana Favorite	Ind.	rob	ml	yrs	msa	gvg	dm	l				*														
Iowa Beauty	Iowa?.	rob	l	wrs	msa	vg		me									*									
Iowa Blush	Iowa?.	rc	l	rs	sa	g	k	ml								†	*									
Irish Peach (*Peach, Peach Apple*)	Eur.	rob	m	ygb	sa			me	*	*																
Isham (*Isham Sweet*)	Wis.	robl	l	r	s	g	km	ml								†		†		†						
Jacobs Sweet (*Jacobs' Winter Sweet*)	Mass.	rob	l	yr	s	vg	dm	l		*																
Jefferis (*Everbearing, Grantham*)	Pa.	obc	m	yrcs	rmsa	vgb	dm	me		**	*	**			*	**		*		*		**		**		
Jersey Sweet (*Jersey Sweeting*)	N. J.?.	roc	m	gyrs	s	gvg	dk	me		*																
Jewett Red (*Nodhead*)	N. H.	rob	m	gwrs	pmsa	gvg		ml	*	*						†										
Jonathan (*New Spitzenberg*)	N. Y.	roblc	m	yrsb	msa	vgb	dkm	ml		**	*	**			*	**	*	**	**	**		**	**	**	**	*
Julian ([illegible])	South.	rc	ml	wrs	psa	gvg		e			*	*														
July (*Fourth of July*)	Ger.	robc	ms	wyrs	bsa	g	km	e			*	*														
Junaluskee	N. C.	rob	ml	yb	rsa	gvg	dk	l				*														
Kaump (*Harry Kaump*)	Wis.	r	l	y		g	km	l								*	*									
Kent Beauty (*Beauty of Kent*)	Eng.	robc	vl	gyrs	sa	g	km	m	*			*				†										
Kentucky Red (*Kentucky Red Crab*)	Ky.?.	obc	s	ydrs	a	g	ck	ml			†	*														
Kernodle (*Kernodle's Winter*)	N. C.	robl	ml	yrs		gvg	dm	vl				*			**											
Keswick (*Keswick's Codlin*)	Eng.	roblc	ml	gyb	a	g	k	me	*	*	*	*				*				†		*	*			
King David	Ark.	rob	m	yrs	sa	gvg	dm	l				†														
Kinnaird (*Kinnaird's Choice*)	Tenn.	obc	m	yr	rsa	vg		ml		*	*	*			**							†				
Kirkbridge (*Kirkbridge White*)	(?)	oblc	ms	wy	sa	g	dk	me		*		*				*				†			*			
Lady (*Lady Apple, Pomme d'Api*)	Fr.	ob	vs	pyb	sa	vg	d	l		*		*								†						
Lady Sweet (*Ladies Sweeting*)	N. Y.	rc	ml	ygrs	s	gvg	dk	l	*	*	*									†						

Section 1.—Apples—Continued.

Subsection 1.—APPLES—Continued.

Name.	Description.								Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Flavor.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Lankford (*Lankford's Seedling*)	Del.?	robl	ml	pyb	sa			l			*	*														
Lansingburg (*Rock Pippin*)	N. Y.	rob	m	yb	msa	g		vl		*	*	*				*										
Late Strawberry (*Autumn Strawberry*)	N. Y.	rc	m	wrs	psa	vg	d	m	*	*		*				*				*		*	*	*		
Lawver (*Delaware Red Winter*)	(?)	robc	l	dr	msa	g		l		*	*	*								*		†	*	*		
Lehigh (*Lehigh Greening*)	Pa.	rob	vl	yg	sa	g	dk	l		*		*														
Lilly (*Lilly of Kent*)	Del	roblc	ml	gy		g	dm	vl			*															
Limbertwig (*Red Limbertwig*)	N. C.?	robc	m	gyrc	a	g	dk	vl		*	*	**	*			*		*	*	*						
Livland Raspberry (*Lowland Raspberry*)	Rus.	oblc	m	yrs	msa	vg	dm	me	**			†				*	**					*	*			
Longfield (*Good Peasant*)	Rus.	robl	ml	yb	sa	g	km	m	*	*		†				*	**				**	**				
Louise (*Princess Louise*)	Ont.	rc	ml	rb	sa	g	d	ml	*	*																
Lowell (*Greasy Pippin*)	Amer.	robc	l	y	ba	gvg	dkm	me		*	*	*				**				†						
Loy (*Loy's Seedling*)	Mo.	ob	l	yrs	sa	g	m	l							*											
Lubsk Reinette (*Lubsk Queen*)	Rus.	rc	ml	wb	a	g		me									†									
McAfee (*McAfee's Nonsuch*)	Ky.	robc	l	ygrsc	msa	gvg	dm	ml			*	*								†		†				
McCuller (*McCuller's Winter*)	N. C.		m			vg						*			*											
McIntosh (*McIntosh Red*)	Ont.	rob	ml	wyrc	sa	gvg	dmk	ml	**	**	*	*				**	*				**	**	*			
McLellan (*McClellan*)	Conn.	robc	ml	yrs	msa	vg		l		*	*					†										
McMahon (*McMahon's White*)	Wis.	robl	l	yw	sa	g	km	m	*	*						*	**	*		*	*	*	*			
Magnate (*Stayman's No. 1*)	Kans.	rc	ml	yr	sa	vg	dm	ml								†										
Magog (*Magog Red Streak*)	Vt.	robl	m	yrs	sa	g		l	*								†									
Maiden Blush (*Maiden's Blush*)	N. J.	rob	m	pyb	sa	g	dkm	m		**	**	**			*	**	*	**	*	**	*	**	**			*
Malinda (*Melinda*)	Vt.	rc	ml	yr	sa	g	dkm	vl	*								**				*					
Mangum (*Magnum Bonum*)	Ala.	obc	m	yrs	sa	vgb	d	m				*														
Mann (*Diltz*)	N. Y.	rob	ml	gy	sa	g	km	vl	*	*	*	*				*	†				*		*			*
Margaret (*Early Red Margaret*)	Eng.	roc	ms	gyrs	sa	g	dm	e			**	*				**				†						
Marshall Red (*Red Bellflower*)	Cal.	robl	l	dr	sa	vg		m																	*	
Melon (*Norton's Melon*)	N. Y.	robc	ml	pyrs	rsa	vgb	dkm	ml		*		*														
Melonen (*Melonenapfel*)	Rus.		l	rs	sa	vg	d	e		†																
Milam (*Rusty Coat Milam*)	South.	rc	ms	grsru	pa	g	dkm	l				*														
Milden (*Milding*)	N. H.	obc	l	rs	sa	g	dkm	ml	†																	
Milwaukee	Wis.	robl	l	yrs	sa	g	km	l								*	*									
Minister	Mass.	oblc	ml	gyrs	ra	gvg	dk	ml		*		*				*										
Minkler (*Mumper Vandevere*)	Pa.?	robc	m	gyrs	sa	g	mk	l				*				**	*	*		*						
Missoula	Mont																					†				
Missouri (*Missouri Pippin*)	Mo.	rob	ml	wyrs	bsa	g	km	l			*	**				**		*	**	**				**	**	**
Mrs. Bryan (*Bryan*)	Ga.	c	l	yr		vg	dkm	m					*		*					*						
Monmouth (*Red Cheek Pippin*)	N. J.	obc	l	pyb	bsa	vgb	dk	ml				*				†						*	**			

Monsees (*Hopewell*)	Mo.	obl	l	rsc		vg	km	l				†				†									
Moore Sweet (*Red Sweet Pippin*)	(?)	rob	m	dr	rpvs	g	dkm	vl		*	*	*				†									
Mother (*Gardener's Apple*)	Mass.	re	m	yrs	rsa	b	d	ml		*		*				*						**	*	*		
Munson (*Munson Sweet*)	Mass. ?	ob	m	pyb	s	g	k	ml	*	*		*														
Nansemond (*Nansemond Beauty*)	Va.	robe	m	yrb	sa			vl			*	*				†										
Nelson (Ill.) (*Nelson Sweet*)	Ill.	rob	ml	gyb	s	g		vl								*	†									
Nero	N. J.?	robl	m	yr	sa	g	km	l			*					†										
Newell (*Orange Winter*)	Wis.	robl	l	yrs		g	km	l									**									
Newtown Spitzenberg (*New York Vandevere*)	N. Y.	robe	ml	yrs	rmsa	vgb	dk	ml		*						†				†		*	*	*		
Nickajack	N. C.	rob	l	yrs	sa	g	km	vl		*					*	†				†						
Northern Spy (*Spy*)	N. Y.	robe	l	gyrs	sa	vgb	dkm	l	**	**	*	*				**		*		*	*	**	**			
Northfield (*Northfield Beauty*)	Vt.	robl	ml	yrs	bsa	vg	dkm	ml	*														*			
Northwestern (*Northwestern Greening*)	Wis.	r	l	yg	sa	g	m	ml	†	*		†				**	**	†		*	*	†				
Oconee (*Oconee Greening*)	Ga.	rob	l	ybru	sa	gvg		m			†	*														
Ohio Nonpareil (*Myer's Nonpareil*)	Ohio	rob	ml	yrs	rsa	vg	dmk	m		*	*	*														
Ohio Pippin (*Shannon*)	Ohio?	rob	l	yb	pa	g	km	ml		*		*				†										
Okabena (*Oakbena*)	Minn.	rob	m	rs	sa	g		ml									**				*					
Oldenburg (*Duchess of Oldenburg*)	Rus.	rob	m	wyrs	ba	g	km	me	**	**	*	**			*	**	**	*		**	**	**	**	**		**
Oliver Red (*Senator*)	Ark.	rob	l	rsc	rsa	vg	dm	ml		†		†				*		†							*	
Ontario	Can.	obe	l	wyrs	sa			vl	*	*																
Ortley (*White Bellflower*)	N. J.	roble	ml	pgy	bsa	gvg	dk	ml		*		*				*				*		*	**		*	
Paragon (*Twitty's Paragon*)	Tenn.	re	l	yr	bmsa	vg	dm	l		†	*	*				†		*		*						
Patten (*Patten's Greening*)	Iowa	rob	ml	yg	sa	vg	dkm	l		†						*	**				**					
Patten Fameuse (*Patten's Fameuse No. 1*)	Iowa																†									
Payne (*Payne's Keeper*)	Mo.	r	l	gyrs	ms	g	m	l				†						*		*						
Peach (Montreal) (*Montreal Peach*)	Fr.	re	ml	rs	sa	vg	dm	m	**	*						†	*									
Peck (*Peck's Pleasant*)	R. I.	rob	ml	gyb	sa	vgb	dkm	ml		*	*	*				*				*						
Peerless	Minn.	rob	l	grs	psa	vg	dk	m		†							**									
Perfection	Minn.	r	vl	yrs	sa	g	km	m									*									
Perry Russet (*Golden Russet*)	(?)	re	m	yru	bsa	gvg	dkm	ml		*	*					*	*									
Pewaukee	Wis.	rob	ml	yrs	ba	g	k	l	*	*		*				*	†			*	*			*		
Plumb Cider (*Plumb's Cider*)	Wis. ?	re	m	gyrs	sa			ml	†	*	*						**	*		*	†					
Pomme Grise (*Gray Apple*)	Can. ?	rob	s	gru	rsa	vgb	d	ml	*	*												*				
Porter (*Yellow Summer Pearmain*)	Mass.	oble	ml	y	sa	vgb	dkm	me	**	*	*	*				*				*			*			
Primate (*Sour Harvest*)	N. Y. ?	robe	m	gwb	sa	vgb	d	me		*	*	*														
Pryor (*Pryor's Red*)	Va. ?	rob	m	gyru	vrsa	vg	dkm	ml				*				*										
Pumpkin Sweet (*Lyman's Pumpkin Sweet*)	Conn.	r	vl	wg	vs	g		m	*	*		*				†										
Ralls (*Janet, Rawle's Genet*)	Va. ?	obe	m	yrsc	psa	gvg	dkm	vl		*	*	**				*	†	*		*						
Rambo (*Bread and Cheese*)	Pa.	rob	m	ywrs	rmsa	vg	dk	m		*	*	**				*		*		**		*		*		
Ramsdell (*English Sweet of Downing*)	Conn. ?	oble	ml	rsc	s	g		ml		*	*	*				*	*			*						
Red Astrachan (*Abe Lincoln*)	Rus.	re	ml	gyre	a	gvg	dkm	e	**	**	**	**	*	*	*	*	*	*		*	*	**	**	**	**	**
Red Canada (*Canada Red, Steele's Red*)	Conn. ?	obe	m	yrsc	bsa	vg	dm	vl	*	*		*				†				†						
Red June (*Carolina Red June*)	N. C. ?	oble	ms	yre	msa	gvg	dm	e		*	*	**	**	*	**	*	†	*	*	**		*	*	**	**	**
Redstripe (*Carolina Red Stripe*)	Ind. ?	oble	m	wrsc	psa	gvg	dkm	me		*		**				*				*						
Repka Malenka (*Little Seedling*)	Rus.	re	s	rs	msa	g	k	ml								†	†									
Rhode Island Greening (*Greening*)	R. I.	robe	l	pyg	ba	vg	dkm	ml	**	**		*			*			*		**	*	**	*	**	**	**
Ribston (*Ribston Pippin*)	Eng.	re	ml	ybru	a	vg	d	l	*	*	*	*														
Rolfe (*Macomber*)	Me.	ob	m	rs	sa	g		ml	*	*	*															
Roman Stem	N. J.	r	m	ybru	prsa	gvg	d	ml		*	*	*				**	*			*	*					
Rome Beauty (*Gillett's Seedling*)	Ohio	robe	l	yrs	psa	vg	dm	ml		*	**	**			*	*		*	*	**		**	**		*	**
Roxbury (*Roxbury Russet*)	Mass.	rob	ml	yru	ra	gvg	km	vl	*	**	*	*			*					*						

Section 1.—Apples—Continued.

SUBSECTION 1.—APPLES—Continued.

Name.	Description.								Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Flavor.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Rutledge	Tex.		l	rs		vg		l							†											
Saint Johnsbury	Vt.	rob	m	yrs	s	vg	dkm	l	*	*																
Saint Lawrence (*Montreal*)	Can.?	obc	m	yrsc	sa	gvg	dm	m	**	*	*					†	*			†						
Salome	Ill.	oblc	m	pyrs	sa	vg	dkm	vl				*				*	*									
Scott Winter (*Scott's Winter*)	Vt.	rc	m	rs	a	g	mk	vl	*	*							*	*		*	†					
Shiawassee (*Michigan Beauty*)	Mich.	rob	m	wrsc	bsa	vg	dm	ml	*	**		*				†	†					*	*			
Shockley (*Dixie, Horse Bud*)	Ga.	rc	ms	pyrb	rmsa	vg	d	vl			*	*	**		*	†										
Skinner (*Santa Clara King*)	Cal.	obc	l	rs	sa	gvg	dk	m																	*	*
Smith Cider (*Smith's Cider*)	Pa.	robe	ml	yrs	pmsa	g	m	ml		*	*	*				*		*		*		*	*	*	*	*
Smokehouse (*Red Vandevere*)	Pa.	rob	ml	yrsc	sa	g	km	ml		*	**	*								*						
Sops of Wine (*Sops in Wine*)	Eur.	r	m	yrs	psa	g	d	me	*	*	*	*				*		*		*						
Stark (*Robinson, Yeats*)	Ohio	rc	l	gyrs	msa	g	km	l	*	*	*	*				*				*						
Starkey	Me.	obc	m	pyrs	psa		km	ml	*	*	*	*														
Starr	N. J.	rob	ml	gw	psa	g	k	me			†														*	
Stayman Winesap (*Stayman*)	Kans.	obc	ml	gyrs	rma	vg	dm	l		†	**	**	*			**	*	*		*		**	*			*
Stephenson (*Stephenson's Winter*)	Miss.	rob	m	gyrs	psa	g		l			*	*	*													
Sterling (*American Beauty*)	Mass.	rc	l	yr	rsa	vg	dm	vl		*						†										
Stone	Mich.	rc	l	rs	s	g		l	†																	
Summer Extra	Ky.	robl	ml	yrb	sa	vg		e								†										
Summer Hagloe (*Hagloe*)	(?)	ob	ml	wyrs	sa	gvg	dkm	me		†	*	*														
Summer King (*Summer Cheese*)	N. C.?	rob	ml	yrc	bsa			me			*	*														
Summer Pearmain (Am.) (*American Summer Pearmain*)	Amer.	roblc	m	yrsc	rpma	vgb	d	me		*	*	*			*	*				**						
Summer Queen (*Early Queen*)	N. J.?	rc	l	yrs	ra	vg	km	me		*	*	*			*	*				†						
Summer Rose (*Woolman's Early*)	N. J.	rob	ms	wyrs	sa	vg	dk	me		*	*	*	*			*				†		*	*			
Sutton (*Sutton's Beauty*)	Mass.	robc	ml	pyrsc	sa	vg	dkm	ml	*	*	*	*				†				*			*			
Swaar (*Hardwick*)	N. Y.	rob	l	gy	rsa	vgb	dk	ml		*												*	*	*	*	
Swayzie (*Swayzie Pomme Grise*)	Can.	robl	s	yru	sa	vg	dk	l	*	*																
Sweet Winesap (*Henry Sweet*)	Pa.	obc	m	rc	rs	gvg		l		*							*									
Switzer (*Suislepper*)	Rus.	rob	m	y	sa	vg	dm	ml	*	*		†				†	*				**					
Taunton	Ala.?	obc	l	gyrs	a	g		m				*	*													
Terry (*Terry Winter*)	Ga.	rc	s	yr	bsa	vgb	dm	l				*	**		**											
Tetofski (*Tetofsky*)	Rus.	robc	ms	yrs	a	g	km	mc	**	*		*				*	**				**					
Texas Red	(?)		l	rs		g		l							†											
Titovka (*Titus Apple*)	Rus.	obobl	l	rs	sa	g	km	me	*	*										†	**					
Tolman (*Talman Sweet*)	R. I.	rc	m	wyb	s	vg	dk	vl	**	**		*				*	*			*	*	*	*			
Tompkins King (*King of Tompkins County*)	N. Y.?	obrc	l	yrs	sa	vg	dm	l	*	**	*	*								*		**	**	**		**

Townsend (*Hocking*)	Pa.	obe	m	pyrs	sa	gvg	d	me		*	*				†											
Trenton Early (*English Codlin*)	(?)	obe	ml	pyg	bsa	gvg	dk	me		*		*			*	*	†			*						
Twenty Ounce (*Cayuga Red Streak*)	Conn.	re	vl	gyrs	psa	gvg		ml	*	*	*	*								†						
University (*Duchess No. 103*)	Iowa.	ob	l	yb	psa	vg		m									†									
Utter (*Utter's Red*)	Ill.?	ob	ml	pyrs	psa	g		ml								*	*	*		*						
Vacaville	Cal.																								†	
Vanhoy (*Van Hoy No Core*)	N. C.	robl	vl	yrs	sa	vg	dm	l			*	*														
Virginia Beauty	Va.	re	ml	gyrs	sa	vg	d	l				†														
Virginia Greening (*Virginia Pippin*)	Va.?	ob	l	gyb	psa	g	km	vl				*									†				*	
Wagener (*Wagoner*)	N. Y.	rob	ml	yrse	bsa	vgb	dkm	l	*	**		*				*		*		*		**	**	**	*	*
Walbridge (*Edgar Redstreak*)	Ill.	obe	m	wyrs	sa	g		vl	†	*		*				*	*	*		*		†	*	*		
Washington Strawberry (*Juniata*)	N. Y.	re	l	yrse	sa	vg		m		*	*	*														
Watson (*Autumn Seeknofurther*)	Ind.?	ob	m	gwrse	rsa	vg	d	me			*	*			*											
Wealthy	Minn.	rob	m	wrse	bsa	vg	dm	m	**	**	**	**			*	**	**	**		**	**	**	**	**		
Westfield (*Westfield Seeknofurther*)	Conn.	re	l	grsru	rsa	vgb	dkm	ml	*	*		*				*	†			*						
White Astrachan (*Astracan*)	Rus.	r	m	wrs	sa	pg		me																**	**	*
White Juneating (*Yellow May*)	Eng.	rob	s	gy	bsa	g	dm	ve				*	**													
White Pearmain (*White Winter Pearmain*)	(?)	roble	m	pyb	pmsa	vgb	dkm	ml		*		*				*		*		**		*	**	**	**	*
White Pigeon (*Golubuno*)	Rus.	robe	ml	rs	sa	g		e	*	*							*									
White Pippin	(?)	rob	l	gw	bsa	vgb	dkm	l		*	*	**				*				†		*	*		*	
Williams (*Williams' Favorite*)	Mass.	roble	ml	dr	sa	vg	m	me	*	**	*	*	*			†				*						
Willow (*Willow Twig*)	Va.?	robe	ml	yrs	psa	g	m	l		*	*	*				*		*	*	*	*	*	*	*		
Windham (*Windham Russet*)	Mass.	re	m	yru	sa	g		vl		†																
Windsor (*Windsor Chief*)	Wis.	re	ml	yr	sa	g	m	ml		*						*	**									
Wine (*Hays' Winter Wine*)	Del.	rob	ml	yrs	sa	gvg	mk	ml			*	*				*				*		†	*			
Winesap (*Winter Winesap*)	N. J.	roble	m	drs	msa	vg	dme	vl		*	**	**	*		*	**	*	**	**	**		**	**	*	*	**
Winter Paradise (*Winter Sweet Paradise*)	Pa.	rob	l	gyb	s	vg	k	l												*						
Winter Saint Lawrence (*Mank's Codling*)	Eng.	re	ml	rs	sa	vg	d	l	†																	
Wismer (*Wismer's Dessert*)	Can.	r	ml	yrs			d	l		†																
Wolf River	Wis.	robe	vl	gyrs	sa	g	km	ml	**	*		*				*	**	*		**	*	*	*			
Wythe (*Illinois Pippin*)	Ill.	obe	m	wrs	sa	vg	d	l	†							†				†						
Yahnke (*Winter King*)	Minn.	re	ml	yres	sa	vg		l									†									
Yates (*Red Warrior*)	Ga.	obe	s	wyrs	psa	g	dm	vl				*	**		*											
Yellow Bellflower	N. J.	oble	vl	pyb	sa	vg	dkm	ml	*	*	*	*						*		**		**	*	**	**	**
Yellow June (*White June*)	South.	rob	ms	py	bsa	g		e			*	*				*										
Yellow Newtown (*Albemarle, Newtown Pippin*)	N. Y.	rob	ml	gy	ba	vgb	dkm	vl		*	*	*						*	*	*		**	**	**	**	**
Yellow Transparent (*White Transparent*)	Rus.	robe	m	py	sa	gvg	dkm	me	**	**	**	**	**			**	**	**	*	**	**	**	**		*	**
York Imperial (*Johnson's Fine Winter*)	Pa.	rob	ml	wes	sa	gvg	km	ml		*	**	**			*	**	†	**	**	**		*	*			*

Section 1.—Apples—Continued.

SUBSECTION 2.—CRABS.[a]

Name.	Description.								Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Flavor.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Alaska (*Kenyon*)	Iowa	r	l	y	sa	g		l					*													
Ball (*Ball's Winter*)	Vt								*																	
Be[illegible]n	Vt	r	l	wy		g	k	vl		†							**									
Brier (*Brier's Sweet*)	Wis	rc	ml	rs	s	vg	dk										*			†						
Dartmouth	N. H		ml	y			kc			*																
Elgin (*Geneva, Lady Elgin*)	Ill	rob	l	wyrb	sa	vg	dk	vl	*	†		*						*		†						
Excelsior	Minn	r	ml	rs	s	vg	d	m		†																
Florence	Minn	ob	ml	rs	a	vg	k	m		†		**	**			*	**	**		*						
Gibb (*Gibb's Golden*)	Wis	rob	vl	y	sa			e	**		*						**									
Grant (*General Grant*)	Minn	rob	l	rs	sa			l				†														
Hyslop (*Hyslop's*)		rc	l	dr	sa	g	kc	m	*	**	**	**			*	**	**			**	**	*				
Island Gem	Vt	r	ml	r		vg	dk	m	*	*																
Jumbo	Vt	obl	vl	yr		vgb	dkm	l	*	*																
Lyman (*Lyman's Prolific*)	Minn	rc	l	yrs	sa		k	m									*				*					
Marengo (*Marengo Winter*)	Ill	rob	l	yrb	sa	g	dm	vl	*	*						†										
Martha	Minn	ob	ml	y		vg	dkc		**	**		†				*	*			*	*					
Minnesota (*Minnesota Prince*)	Amer	obl	l	y	sa	vg	km	l	**	†							**			†	*					
Montreal (*Montreal Beauty*)	Amer	rob	l	yrs	sa	g	k	ml	*	*	*									†						
Orange		rob	m	y	sa	g	k	l	*	†	*						†						*			
Powers (*Powers's Large Red*)	N. Y	rob	l	wyrs	a	g	k	ml	*																	
Pringle (*Pringle Sweet*)	Can	rob	m	rs	s	vg	dkm	m									†									
Queen (*Queen Choice*)		r	m	r		vg	km	l	*	†																
Red (*Red Siberian*)	Eur	rob	ml	yr	sa	g	km	m	**	*	*	**	*		*	*				†			*			
Shields	Wis		l	rs													†									
Soulard Crab[b]	Mo	ob	l	gy	a		c										†									
Stanstead (*Rose of Stanstead*)	Can	obl	ml	r	sa	vgb	dk	l	*																	
Sweet Russet (*Summer Sweet Russet*)	Wis		vl	ru		vg		e									**									
Transcendent	Amer	robl	ml	gyb	sa	g	km	me	**	**	**	**	**			**	**	**		**	**	*	*			
Van Wyck (*Van Wyck's Sweet*)	N. Y	rc	l	wb	s	g		m	*	*		†								†						
Virginia		ob	m		sa	g	km										**									
Whitney (*Whitney's No. 20*)	Ill	rc	l	yrs	sa	g	k	ml	*	**	*	**			**	**	**			*	**		**			
Yellow Siberian (*Amber*)	Eur	r	s	y	a	g	k	m	*	†	*	**	*			*		*		*	*					

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[a] Includes such possible hybrids as strongly manifest crab parentage.

[b] This is a native American wild crab.

Section 2.- APRICOTS (*Prunus*).

[KEY. *Origin:* Afr., Africa; Amer., America; Eur., Europe; Fr., France; N. Y., New York, etc. *Form:* c, compressed; co, conical; ob, oblate; obl, oblong; r, round. *Size:* l, large; m, medium; s, small; v, very. *Color:* b, blushed; c, crimson; o, orange; r, red; w, white; y, yellow. *Adhesion:* c, cling; f, free; se, semicling. *Quality:* b, best; g, good; p, poor; v, very. *Use:* d, dessert; k, kitchen; m, market. *Season:* e, early; l, late; m, medium; v, very.]

Name.	Description.								Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Adhesion.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Acme (*Chinese, Shense*)		r	m	cw	f	gvg	dkm	e														*				
Alexander (*Russian No. 2*)	Rus.	obl	m	oy		g	dm	m														*	*			
Blenheim (*Shipley's*)	Eng.	ob	ml	oy		gvg	dm	m														**	**	**	**	**
Breda (*Ananas, De Hollande*)	Afr.	rob	s	o	f	vg	dm	m		*	*	*								*						
Cluster	Tex.														*											
Early Golden (*Dubois*)	N. Y.?	rob	s	o	f	vg	d	e		†	†	†			*	†				*						
Harris (*Harris Hardy*)	N. Y.	oblco	m	or		g	dm	ve		*																
Hemskirke	Eng.	robc	vl	orb	f	gvg	d	ve												†		**	**	**	**	**
Large Early (*Gros Precoce*)	Fr.	oblco	ml	or	f	gvg	d	e												†						*
Moorpark (*De Nancy*)	Eng.	r	vl	or	f	gvg	d	m		*	*	*			**	*				**		**	**	**	*	*
Newcastle (*Newcastle Early*)	Cal.	r	m	oy	f	g		me												*			**	**	*	*
Orange (*Early Orange*)	Eur.	obr	m	or	se	gp	k	e			†	*								*						
Peach (*Royal Peach*)	Italy	rcoc	vl	yo		vg	d	m		†										*		*	**	**	*	*
Royal (*Abricot Royal*)	Fr.	robc	l	yor		vg	d	ve		*		†			*	†				*		**	**	**	**	**
Russian																†										
St. Ambroise	Fr.?	rc	vl	yr		vg	d	ml		*										†						
Sheridan															†											
Superb																				†						
Tilton	Cal.																						**	*	*	*

Section 3.—BLACKBERRIES AND DEWBERRIES (*Rubus*).

[KEY. *Origin:* Amer., America; Cal., California; Ind., Indiana; Tex., Texas, etc. *Form:* c, conical; obl, oblong; ov, oval; r, round. *Size:* l, large; m, medium; s, small; v, very. *Color:* a, amber; b, black; r, red; w, white; y, yellow. *Quality:* b, best; g, good; v, very. *Use:* d, dessert; k, kitchen; m, market. *Season:* e, early; l, late; m, medium; v, very.]

SUBSECTION 1.—BLACKBERRIES.

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Acme																			*						
Agawam	Amer.	robl	l	b	bvg	dm	e	*	**										†						
Allen	Pa.	rc	l	b	vg	dm	ve		*																
Blowers									†						†										
Briton (*Ancient Briton*)	Wis.	ovr	m	b	g	m	m		*	*					**	**	*		**		†				
Brunton	Amer.	obl	ml	b	vgb	dm	e		*																
Cox	Tex.	r	m	br	g		e							†											
Crandall (*Crandall's Early*)	Tex.						ve														†		**	**	**
Dallas	Tex.		l	b	vg	dkm	m				†	**		*											
Early Harvest	Ill.	robl	s	b	vg	dm	e		*	**	**	**		**	**		**		*		*			*	
Eldorado	Ohio	obl	vl	b	vg	dkm	e		**	*	†				**	*	*				*				
Erie	Pa.	robl	lvl	b	g	m	m		*	*	†	*		**	**		*		*		**				
Evergreen	Oreg.?		l	b	vg		vl															†		*	
Gardenia																							*		†
Haupt														†											
Himalaya																						*		†	
Iceberg	Cal.	robl	l	aw	vg	d	m					†			†										
Illinois															†										
Kenoyer	Kans.														†										
King (*Early King*)			l				ve		*						*										
Kittatinny	N. J.	robl	lvl	b	vg	dm	ml		*	*	*	*		*	†		*		*		*	**		*	*
Lawton	N. Y.	rov	vl	b	vg	dmk	m		*	*	*				*		*		*		*	*	*		*
Logan (*Loganberry*)[a]	Cal.																				**	**	**	**	**
Mammoth	Cal.	obl	vl	b	vg	dkm	ve															*	*	**	**
Mercereau					g				†						*		*								
Minnewaska	N. Y.	ov	vl	b	vg	km	em		*	*	*						*		**						
Montmorency															†										
Phenomenal	Cal.																					†	**	†	
Premier																						†			
Rathbun	N. Y.	obl	l	b	g	km			†																
Snyder	Ind.	obl	ml	b	vg	dkm	ml	**	**	*	**	*			**	**	*		†		*	*			
Stone (*Stone's Hardy*)	Wis.	robl	m	b	vg	d	l	†	*		*	*							*			*			
Taylor (*Taylor's Prolific*)	Ind.	robl	ml	b	vg	d	l	*	*	*	*				**		†		†						
Triumph (*Western Triumph*)	Amer.	oblov	m	b	g	d	l	†																	

Wachusett	Mass.	oblov	ms	b	g	d	e		*						*										
Ward	N. J.	obl	ml	b	vg					†					†										
Wilson	N. J.	oblov	vl	b	vg	m	m		*	*	*	†					*		*		*				

[a] Logan or Loganberry is a blackberry-raspberry hybrid, and is placed with blackberries for convenience.

SUBSECTION 2.—DEWBERRIES.

Lucretia (*Lucretia Dewberry*)	W. Va.	oblov	vl	b	vg	dkm	e		*	**	**	*		**	**		**		**		*		*		*
McDonald														†											
Mayes (*Austin Dewberry, Austin-Mayes*)	Tex.	cov	vl	b	vg	dm	ve			*	**	*		**	*										
Myer (*Myer Dewberry*)																						†			

Section 4.- CHERRIES (*Prunus*).

[Key.—*Origin:* Amer., America; Eng., England; Eur., Europe; Fr., France; Ger., Germany; Ont., Ontario; Rus., Russia, etc. *Form:* c, compressed; h, heartshaped; o, oblate; r, round. *Size:* l, large; m, medium; s, small; v, very. *Color:* a, amber; b, black; d, dark; p, purple; r, red; w, white; y, yellow. *Quality:* b, best; g, good; v, very. *Use:* d, dessert; k, kitchen; m, market. *Season:* e, early; l, late; m, medium; v, very.]

SUBSECTION 1.—HEART AND BIGARREAU CHERRIES.

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Bing	Oreg.		vl	b	vg	dm	l		†												**	**	**	**	**
Black Heart	Eur.?	ch	l	b	g	dm	ve		*	*	*	*							†						
Centennial	Cal.	oh	vl	yr	vg	dm					*	*									†	**	**	*	*
Chapman (*California Advance*)	Cal.	h	l	b	vg	dm	e															*	*	*	**
Cleveland (*Cleveland Bigarreau*)	Ohio.	ch	ml	yr	g		m					*													
Coe (*Coe's Transparent*)	Conn.	r	m	yr	vgb	d	e		*	*	*								†						
Downer (*Downer's Late Red*)	Mass.	rh	ml	r	vg	dm	ml		*	*															
Eagle (*Black Eagle*)	Eng.	oh	ml	b	gvg	dm	m		*	*		*													
Early Purple (*Early Purple Guigne*)	Eur.	rh	sm	pb	gvg	d	ve		*		*											**	**	*	*
Elkhorn (*Black Oxheart*)	(?)	h	vl	b	vg	dm	l		*																
Elton	Eng.	h	lvl	yr	vg	dm	e		*	*		*									**				
Hoskins	Oreg.	rh	vl	pr	vg	dm	lm														**	*			
Ida			ml	yr	vg		e			†	†														
Knight (*Knight's Early*)	Eng.	oh	lvl	b	gvg	d	e		*										*		**	**			*
Lake	Oreg.?		vl		vgb																*				
Lambert	Oreg.	h	l	pr	vg	dm	ml		†												**	**	**	*	**
Lewelling (*Black Oregon*)	Oreg.	rh	lvl	b	vg	dm			*		†										*	*	**		
Mezel (*Black Bigarreau*)	Eur.	oh	vl	rb	vg	d	m		*	*														*	*
Napoleon (*Royal Ann*)	Eur.	h	l	yr	gvg	m	m		*	**	*	*			*		†		**		**	**	**	**	**
Oxheart (*Major Francis*)		oh	ml	r	g	dm	m												*		**				
Republican (*Black Republican*)	Oreg.		ml	b		dm	vl														**	**	**	**	**
Rockport (*Rockport Bigarreau*)	Ohio.	oh	lvl	ra	vg	dm	m		*	*											**		**	**	**
Smith (*Smith's Bigarreau*)									*			*													
Spanish (*Yellow Spanish*)	Eur.	oh	vl	yr	vg	d	em	*	*	*	*				†						*	*			
Tartarian (*Black Tartarian*)	Rus.	h	l	b	vgb	dm	em	*	**	*	*	**			†				*		**	**	**	**	**
Windsor	Ont.	h	ml	yr	gvg	dm	l	*	*	*	†	*			†				*		**				
Wood (*Governor Wood*)	Ohio.	rh	ml	yr	vg	dm	em		**	*	*				*						**	**	*		*

SUBSECTION 2.—DUKE AND MORELLO CHERRIES.

Amarelle Hative (*Morello Hative*)	Rus.	r	ml		g	m	e	†								†									
Angouleme (*Duchess of Angouleme*)	Rus.	roh	m	r	g	km	e								†	†									
Archduke	Eur.	oh	ml	r	vg	dk	em		*										†						
Baldwin	Kans.?	r	m	dr	g	k	me				†						†								
Bessarabian (*No. 62*)	Rus.	r	m	r	g	k	l	†	*							*									
Carnation (*English Bearer*)	Eur.	r	l	vr	g	k	em	*	*		*				*		*								
Choisy (*Belle de Choisy*)	Fr.	r	ml	ra	vgb	d	e		*	*	*								*						
Dyehouse	Ky.	ro	m	r	g	k	ve		**	*	**	**			*	†	*		*		†		†		
Eugenie (*Empress Eugenie*)	Fr.	r	lvl	ra	vg	d	e	*	*		*	*													
Homer	Conn.															†				†	†				
Hortense (*Reine Hortense*)	Fr.	rh	vl	r	vg	dm	ml		*	*	*	*													
King (*King Amarelle*)		r	m	r	g	km	l										*								
Large Montmorency	Fr.	ro	ml	r	vg	km	em	†	**	**	**	*			**	*	**		*		*		*		
Late Duke (*Angloise Tardive*)	Eng.	oh	ml	r	gvg	k	l		*	*	†								*	*	**	*			
Late Kentish	Amer.	r	m	r	g	k	lm		*	*					*						*	*	*		
Lithauer (*Lithauer Weichsel*)	Rus.	ro	s	r	g	k			†																
Lutovka (*Galopin*)	Rus.	r	ml	r	g	k	em	*	†						†	†			†						
Magnifique (*Belle Magnifique*)	Fr.	rh	ml	r	gvg	k	l		*	*															
May Duke (*Early Duke*)	Fr.	rh	ml	r	vg	dk	e	†	**	**	*	*					†		*		**	**	**	*	**
Miller																	*								
Montmorency (*Montmorency Ordinaire*)	Fr.	r	l	r	vg	km	em	†	**	**	**	*		*	**	*	*		**		**				
Montreuil (*Belle de Montreuil*)	Fr.	h	l	rb	vg		m		*																
Morello (*English Morello, Wragg*)	Eng.?	rh	ml	rb	g	km	l	*	**	**	**	**			**	**	**		**	**	**		**		*
Olivet	Fr.	r	ml	r	g	dk	e		*	*	†										†		†		
Ostheim (*Russian Cherry*)	Rus.	er	mi	rb	g	dkm	m	†	*		*	*			*	*	*		*		†				
Philippe (*Louis Philippe*)	Fr.	r	ml!	r	g	k	e		*	*	†				†				†		†		*		
Plumstone (*Plumstone Morello*)	Amer.	rh	ml	r	g	k	m								*				†						
Richmond (*Early May, Early Richmond*)	Eur.?	r	m	r	g	km	e	**	**	**	**	**		*	**	**	**		**	**	**	*	*		*
Royal Duke	Fr.	rh	ml	r	gvg	dk	e	*	*	*	*	*							*						
Shadow Amarelle	Eur.	r	ml	r	g	m	m	†								†									
Suda (*Suda Hardy*)	Mo.	c	ml	r	vg	dkm	m				*				†					**					
[illegible]	Ger.?	o		r			me								†	†									
Vladimir	Rus.	r	ms	rb	g				†		†	*													

Section 5.—CURRANTS (*Ribes*).

[Key.—*Origin:* Amer., America; Eng., England; Eur., Europe; Fr., France; Ont., Ontario, etc. *Form:* ov, oval; r, round. *Size:* l, large; m, medium; s, small; v, very. *Color:* b, black; r, red; w, white. *Quality:* b, best; g, good; v, very. *Use:* d, dessert; k, kitchen; m, market. *Season:* e, early; l, late; m, medium.]

Subsection 1.—RIBES NIGRUM and R. AUREUM.

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Champion (*Black Champion*)	Eng.	r	vl	b	gvg	km	em	*	*		*				*	*				*	*				
Crandall (*Crandall's Black*)	Kans.	rov	vl	b	gvg	k	l				†	*			†										
English (*Common Black*)	Eng.	r	m	b	g	km	m		*							*			†						
Lee (*Lee's Prolific*)	Amer.?	r	ml	b	vg	km	m	*	*	*	*				*	*			†	*					
Naples (*Black Naples*)	Eur.	r	ml	b	g	km	m	*	*	†						*				*					
Saunders (*Saunder's Seedling Black*)	Ont.	r	ml	b	g	km	m	*	*							†				*					
Wales (*Prince of Wales*)	Ont.	r	ml	b	g	km	m	*	†		*				†	*				*					

Subsection 2.—RIBES RUBRUM.

Name.	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Albert (*Prince Albert*)	Eur.	r	l	r	vg	dm	e	*	*		†					*			*						
Cherry	Eur.	r	vl	r	g	m	m	**	**	**	**				**	*	*		**	**	**	*			
Defiance		r		r													*								
Fay (*Fay's Prolific*)	N. Y.	r	vl	r	g	m	m	**	**	**	**				**	*	**		**	**	**	**	*		
Holland (*Long Bunch Holland*)	Eur.	r	ms	r	g	km	em		*						*	**			*	*					
London (*London Market*)	Eng.	r	ms	r	g	km	m		*							**			*	*					
Moore Ruby (*Moore's Ruby*)	N. Y.	r	vl	r	vg	km	m	†	†	*															
North Star	Minn.	r	m	r	g	km	m		*							**	*				*				
Perfection									†						**	*					†				
Pomona				r	vg				*							**									
Raby Castle [Probably same as Victoria]		r	ml	r	vg	km	m		†																
Red Cross	N. Y.	r	vl	r	vgb	dm	m	*	**							*	*		†		*				
Red Dutch (*Large Red Dutch*)	Eur.	r	ml	r	vg	dm	m	*	*	*	**				**	**	**		**	**	*		*		
Red Grape	Eur.?	r	m	r	vg	km	m	*								*	*		†	*	*				
St. Giles (*Belle de St. Giles*)		r	vl	r	vg	km	m		†			†													
Versaillaise (*La Versaillaise*)	Fr.	r	vl	r	g		m	*	*	*					*	*			**	*					
Victoria (*May's Victoria*)	Eng.	r	m	r	g	m	m	*	*	*	*				**	**	*		*	*		*			
White Dutch (*White Antwerp*)	Eur.	r	ml	w	vgb	d	m	*	*	*	*				*	*			**	*		**			
White Gondouin (*Gondouin White*)	Eur.	r	ml	w	vgb	d	m		*	*									†						
White Grape (*Imperial White*)	Eur.	r	l	w	vg	m	m	**	*	*	**				**	**	*		*	*	**	**			
Wilder (*Wilder Red*)	N. Y.	r	vl	r	g	m	m	**	**	**	*				*				†						

Section 6.—GOOSEBERRIES (*Ribes*).

[KEY. *Origin:* Amer., America; Eng., England; N. Y., New York; Ont., Ontario, etc. *Form:* obl, oblong; ov, oval; r, round. *Size:* l, large; m, medium; s, small; v, very. *Color:* g, green; r, red; w, white; y, yellow. *Quality:* b, best; g, good; v, very. *Use:* d, dessert; k, kitchen; m, market. *Season:* e, early; l, late; m, medium.]

SUBSECTION 1.—RIBES RECLINATUM (R. GROSSULARIA).[a]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Berkeley (*Dwinelle*)	Eng.?		l																*				*		
Chautauqua	N. Y.	robl	l	gw	vgb	km	m		*	*					†	*	*		*						
Columbus (*Triumph*)	Amer.	rov	l	gy	vgb	km	m	†	*	*					†	*	*								
Crown Bob	Eng.	ov	l	r	vg	km	e		*	*					*	*			†						
Industry (*Wyndham's Industry*)	Eng.	rov	vl	r	vg	km	e	*	*		*				†	*	*		*	**	†	*			
Keepsake	Eng.	obl	ml	g	vg			†																	
Wellington (*Wellington's Glory*)	Eng.	ov	lvl	gw	g	km	e		*						†	*									
Whitesmith (*Sir Sidney Smith*)	Eng.	ov	lvl	gw	g	km	e	*	*										*						

a Includes American seedlings of this parentage.

SUBSECTION 2.—RIBES OXYACANTHOIDES.[b]

Name.	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Carrie	Minn.		l	r											†	*									
Champion (*Mills' Champion*)	Amer.	rov	m	gy	g	km	m		*	*					*	*	*		*		**	**	*		
[illegible]															†	†									
[illegible]															†										
Downing (*Downing's Seedling*)	N. Y.	r	ml	g	g	km	m	**	**	*	**				**	**	**		**	*	*	*			
Houghton (*Houghton's Seedling*)	Mass.	rov	s	gr	gvg	dk	m	**	*	*	**				**	**	*		**	**	**		*		
Josselyn (*Red Jacket*)	Ont.	rov	ml	r	vg	km	e	*	**	*	*				**	*			**						
Mathews																†									
Oregon (*Oregon Champion*)	Oreg.?	obl	m	g	g	k													*						
Pale Red (*American Red*)	Amer.	rov	s	r	vgb	dk	m		*		*				*				†						
Pearl	Ont.	r	m	g	vgb	dk	m	**	*						*	**	*		†	*					
Poorman																	*								
Smith (*Smith's Improved*)	Vt.	ov	m	yg	vg	dk	e	*	*	*	*				*	†	*		**	*	†				

b Includes apparent hybrids of this with other species.

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Section 7.—GRAPES (*Vitis*).

[Key.—*Origin:* Amer., America; Eng., England; Eur., Europe; For., Foreign; Fr., France; Ont., Ontario, etc. *Form:* o, oval; obl, oblong; r, round. *Size:* l, large; m, medium; s, small; v, very. *Color:* a, amber; b, black; g, green; r, red; w, white; y, yellow. *Quality:* b, best; g, good; p, poor; v, very. *Use:* d, dessert; k, kitchen; m, market; r, raisins; w, wine. *Season:* e, early; l, late; m, medium; v, very.]

Subsection 1.—VITIS AESTIVALIS.

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Northern Group.																									
Cynthiana (*Red River*)	Ark.	r	s	b	vg	w	e				*	*		*	*										
Eumelan	N. Y.	r	m	b	vg	d	m		*		*														
Gold Coin	Tex.	r	ml	w	vg	dm	me							*											
Hopkins	Tex.	r	m	b	vg	dw	m								†										
Norton (*Norton's Virginia*)	Va.	r	s	b	g	w	e			*	*			**	*										
Superb	Ga.	r	l	b	vg	dm	ml				†	*													
Wetumka	Tex.	r	l	yg	g	dmw	l					†													
Southern Group (*V. Bourquiniana*) of Munson.																									
Delaware	N. J.?	r	s	r	b	dm	m	*	**	*	**	**	*	*	**	**	**		**		**	**			
Herbemont (*Warren*)	South.	r	s	b	vg	dw	l				*		*	*	*				†						
Lenoir (*Jacques*)	N. C.	r	s	rb	g	dm	l						*	**											
Moyer (*Jordan*)	Can.	r	s	r	vg	dm	m		*																
Perry	Tex.												†												
Wylie (*Peter Wylie*)	S. C.	r	s	yr	vg	d	ve							*											

Subsection 2.—VITIS LABRUSCA.[a]

Name.	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Agawam (*Rogers' No. 15*)	Mass.	ro	vl	rb	vg	dm	m		*	*	*	*			*	*	*		*		†	**			
Barry (*Rogers' No. 43*)	Mass.	r	vl	b	vg	dm	m		*						*				†						
Brighton	N. Y.	r	l	r	vg	d	e	**	**	**	**	**			**	**	†		*		†	*			
Brilliant	Tex.	r	ml	r	vg	dm	e			*	*			**		†									
Campbell (*Campbell Early*)	Ohio.	r	l	b	vg	dm	e		*	†	*					**	*				*	**			
Catawba (*Red Muncy*)	N. C.	r	l	r	vg	dm	vl		*	*	*	*	*	*	*		*		†			*			
Champion (*Early Champion*)	Amer.	r	m	b	g	m	ve		*	*				*					†						
Concord	Mass.	r	ml	b	g	m	m	**	**	**	**	**		**	**	**	**		**		**	**			*
Cottage	Mass.	r	l	b	g	m	m		*	*	*	*			*				†			*			
Daisy (*Daisy Early*)	Kans.?	o	l	r	g	dm	e		†																

Dawn (*Early Dawn*)	N. Y.	r	m	b	vg	dm	e		†																
Diamond (*Moore's Diamond*)	N. Y.	r	m	gw	vg	dm	m		**	*	*	*	*	*	**	*			†		†	**			
Diana	Mass.	ro	m	r	vg	d	m		*		†	*							†						
Duchess	N. Y.	ro	sm	gy	vgb	d	m		*										*						
Eaton	Mass.	r	l	b	g	m	ml			†															
Empire (*Empire State*)	N. Y.	r	ms	w	vg	d	m		*	*					†	†			†						
Gaertner (*Rogers' No. 14*)	Mass.		ml	r	vg	d	me			†	†	*													
Goethe (*Rogers' No. 1*)	Mass.	o	vl	ygr	vg	d	l		*	†	*	*			*				*						
Golden Drop	Vt.	r	s	ywr	vg	d	ve		†																
Hartford (*Hartford Prolific*)	Conn.	r	ml	b	g	m	e	*	*	*	*			*	*				†						
Hayes (*Francis B. Hayes*)	Mass.	r	m	yw	vg	d	e		*		*								†						
Headlight	Tex.	r	l	r	vg	dm	ve			†		*													
Herbert (*Rogers' No. 44*)	Mass.	r	ml	b	vg	dm	e	*	*	*	†								†						
Hidalgo	Tex.	r	l	yw	vg	dm	e			†															
Iona	N. Y.	ro	m	r	vgb	d	m		*								†		†						
Isabella	S. C.	ro	l	b	g	dm	m		*			*							*		†	**			
Ives (*Ives' Seedling*)	Ohio	ro	m	b	g	mw	e	*	*	*	*	*	**	*	*		*		*						
Janesville	Wis.	r	m	b	gp	m	e								*	**									
Jefferson	N. Y.	r	m	r	vg	d	ml		*	†	†		*												
Lady	Ohio	r	ml	w	vg	d	me		*	*							*								
Lindley (*Rogers' No. 9*)	Mass.	ro	m	r	vg	dm	m		*	*	*		*		*		*		*						
Lutie	Tenn.	r	m	r	g	dm	l				*														
McPike	Ill.	r	vl	b	g	m	m		†	†															
Martha	Mo.	r	m	yw	vg	dm	e				*														
Massasoit (*Rogers' No. 3*)	Mass.	r	l	r	g	dm	m	*	*		†								†						
Merrimac (*Rogers' No. 19*)	Mass.	r	vl	b	vg	dm	m		*	†	†				*										
Mills	Ont.	r	l	b	vg	d	m		†			*													
Moore (*Moore's Early*)	Mass.	r	vl	b	g	dm	e	**	**	**	**	**	*	**	**	**	**		**		**	**			*
Murray		r	l	w	vg	dm	ml		*																
Nectar	N. Y.	r	m	b	vg	d	e		*	*															
Niagara	N. Y.	ro	l	w	vg	dm	m	*	**	**	**	*	*	*	**	†	**		**		**	**			*
Olita	Tex.	r	m	w	vg	d	m						*	*					†						
Perkins	Mass.	r	vl	r	p	m	ve		*	†	†			*	*				†						
Pocklington (*Golden Pocklington*)	N. Y.	r	vl	wy	g	m	em		*	†				*	*		†		†		†				
Prentiss	N. Y.	r	m	w	vg	d	m		*	*									*						
Requa (*Rogers' No. 28*)	Mass.	r	m	gwr	vg	d	ml		†																
Rockwood	Mass.	r	l	b	g	m	m			†															
Salem (*Rogers' No. 53*)	Mass.	r	vl	r	vg	dm	m		*	*	*	†							*						
Triumph	Ohio	r	l	y	vg	d	vl								*										
Ulster (*Ulster Prolific*)	N. Y.	r	m	yr	vg	d	m		*	*															
Vergennes	Vt.	o	l	r	vg	dm	m		*	†	*	*					*		†			**			
Victor (*Early Victor*)	Kans.	r	m	b	vg	d	ve		*		*								†						
Washington (*Lady Washington*)	N. Y.	r	ml	yw	vg	d	l			†	†				*										
Wilder (*Rogers' No. 4*)	Mass.	r	vl	b	vg	dm	m		*	*				*					*		†				
Winchell (*Green Mountain*)	Vt.	r	m	w	vg	d	e	*	**	*	*	*			*	†						**			
Woodbury	Me.	ro	m	w	vg	dm	m		*																
Woodruff (*Woodruff's Red*)	Mich.	r	vl	r	g	m	em		*		*				*				†						
Worden (*Worden's Seedling*)	N. Y.	r	l	b	vg	dm	em	*	**	**	**	*	*	*	**	**	**		**		**	**			
Wyoming (*Wyoming Red*)	N. Y.	r	sm	r	g	m	m								†										

a Includes apparent hybrids.

Section 7.—Grapes—Continued.

SUBSECTION 3.—VITIS LINSECOMII.[a]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
America	Tex	r	s	b	g	w	m							*					*						
Beacon	Tex	r	l	b	vg	dm	e							*											
Carman	Tex	r	l	b	vg	dm	vl					*	*	**	*										
Fern (*Fern Munson*)	Tex	r	sm	b	g	w	l							*											
Jaeger (*Herman Jaeger*)	Tex	r	m	b	vg	dm	m						*	*	†										
Laussel	Tex	r	sm	b	vg	dm	vl							*											
Muench	Tex		m	b	g	dm	vl				†	*		*											

[a] Includes apparent hybrids.

SUBSECTION 4.—VITIS ROTUNDIFOLIA.

Name.	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Eden	Ga	r	l	b	vg	dw	l					*													
Flowers (*Black Muscadine*)	South	r	l	b	g	dw	vl				†	**	**												
James	N. C	r	vl	b	vg	d	vl				†	*	**	*											
Memory	South	obl	ml	br	g	m	m						**												
Mish	N. C	o	l	b	g		ve						**												
Scuppernong	N. C	r	vl	yw	g	w	m				*	**	**	**											
Tenderpulp	S. C	r	vl	b	g	w	m				†	†	*	*											
Thomas	S. C	r	l	b	vg	w	e				†	†	**	*											

SUBSECTION 5.—VITIS VINIFERA.

Name.	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Alexandria (*Muscat of Alexandria*)	Africa	obl	vl	yw	vg	dr	l												*		**	**	**	**	**
Black Ferrara	For			b	g	m															*			*	
Black Hamburg	Ger	ro	vl	b	vg	d	m														**	**	*	*	*
Black Morocco	For	o	vl	b	vg	d	l															**	**	*	**
Black Prince	For	o	ml	b	vg	d	e														*	**	*	*	**
Carignane																								*	*
Cornichon (*Black Cornichon*)	Eur	obl	vl	b	vg	d	l												†		†			**	**
Emperor	Eur	obl	vl	r	g	d	l												†		*			**	**
Flame Tokay	Eur	ro	vl	r	vg	d	m												†		**	**		**	**
Gordo Blanco (*Muscatel*)	Spain	r	vl	w	vg	rd	m																	**	*

Malaga (*White Malaga*)	Spain	o	vl	w	vg	dr	m												†				**	**	**
Mission	Cal	r	ml	b	g	dw	m												*		*	*	*		*
Palomino (*Golden Chasselas*)	For	r	ml	gy	vg	d	e																	*	
Peru (*Rose of Peru*)	Eur	r	vl	yg	vg	d	e												†		*	**	**	**	**
Sauvignon blanc																								*	
Semillon																								*	
Sultana (*Seedless Sultana*)	Asia	o	m	y	vg	r	m												†				**	**	**
Sultanina (*Thompson Seedless*)	Tur	o	sm	wy	vg	dr	e												†		*		**	**	
Sweetwater (*White Sweetwater*)	Eur	r	mi	w	vg	d	e												†		**	*	**	**	**
Verdal (*Aspiran Blanc*)	Eur	o	vl	y	vg	d	l														†		**	*	*
Zinfandel	Eur			b	g	w	m												*		*		*	*	**

SUBSECTION 6.—VITIS VULPINA *syn.* RIPARIA.[a]

Bell	Tex	r	vs	w	vg	w	me					*		*											
Berckmans	S. C	r	m	r	vgb	d	m							*					†						
Beta	Minn															*				†					
Clinton	N. Y	r	s	b	g	w	vl	*	*	*	*														
Elvicand	Tex	r	m	r	vg		m												†						
Elvira	Mo	r	s	w	vg	d	m				*				*				†						
Missouri Riesling (*Grein's No. 1*)	Mo	r	m	gw	vg	w	m							*	*										
Noah	Ill	r	vs	w	g	w	vl				†			*											
Rommel	Tex	r	m	w	vg	dm	me							*											

[a] Includes apparent hybrids.

Section 8.—MULBERRIES (*Morus*).

[KEY.—*Origin:* Eur., Europe; N. Y., New York, etc. *Form:* c, cylindrical; l, long; s, short. *Size:* l, large; m, medium; s, small; v, very. *Color:* b, black. *Quality:* b, best; g, good; p, poor; v, very. *Use:* d, dessert; k, kitchen; m, market. *Season:* e, early; l, late; m, medium.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Abundance															†										
Black English	Eur.		l	b			el							†											
Downing	N. Y.	lc	ml	b	vg	dm	el		*	**	**		**	**	**										
Hicks	Ky.	sc	m	b	g	dk	m			†	*		*	**											
Lutie															†										
New American	N. Y.	lc	ml	b	vg	dk	m		**	*	*				*										
Stubbs	South.	lc	vl	b	vgb	d			*				**	**											
Travis	Tex.?													†											
Victoria	Tex.												†	†	†										

Section 9.—NECTARINES AND PEACHES (*Amygdalus*).

[KEY.—*Origin:* Amer., America; Eur., Europe; Jap., Japan; Ont., Ontario, etc. *Form:* c, compressed; f, flat; ob, oblate; obl, oblong; ov, oval; r, round. *Size:* l, large; m, medium; s, small; v, very. *Color:* b, blushed; c, creamy; g, green; r, red; w, white; y, yellow. *Adhesion:* c, cling; f, free; se, semicling. *Quality:* b, best; g, good; p, poor; v, very. *Use:* d, dessert; k, kitchen; m, market. *Season:* e, early; l, late; m, medium; v, very.]

SUBSECTION 1.—NECTARINES.

Name.	Description.								Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Adhesion.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Boston (*Perkin's Seedling*)	Mass.	rov	l	yr	f	g	d	m		*	*					†				*		*		**	**	
Downton	Eng.	rov	l	gr	f	g	d	ve			*									†						
Early Newington (*Early Black Newington*)	Eng.	rov	l	gr	c	vg	d	e		*		*								†					*	
Early Victor										*																
Early Violet (*Violette Hative*)	Fr.	r	l	yr	f	vg	d	ve				*								†						
Elruge (*Common Elruge*)	Eng.	rov	ml	gr	f	vg	d	l		*										†						
Golden (*Fine Gold Flushed*)	Eng.	rov	m	yr	c	g	dk	m												*						
Napier (*Lord Napier*)	Eng.		m	cr	f	g		e																	*	
New White (*Neil's White*)		r	ml	w	f	vg	dm													*				**		
Snow Flake																				*						
Stanwick	Eng.	rov	ml	gr	f	g	d	l		*	*					†				†						

SUBSECTION 2.—PEACHES.[a]

Name.	Origin.	Form.	Size.	Color.	Adhesion.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Albright Cling (*Albright's Cling*)	Cal.		vl	yr	c	vg		l				†											*			
Alexander (*Alexander's Early*)	Ill.	r	m	wr	sc	g		ve		*	*	*	*		*	*	*			*		**	**	**	*	**
Allen (*Allen's Walpole*)	Mass.	r	s	wr	f	g		ml				†														
Alton [This may be Minnie]												†	*		*	*										
Amelia (*Jackson*)	S. C.	robl	l	cwy	f	vg		em			*		*		**	*										
Angel	Fla.	r	l	wr	f	vg	dm	e						**	*											
Augbert	Tex. ?	r	l	yr	f	gvg									†											
Bailey (*Friday Seedling*)	Iowa.				f	g												*								
Banner	Ont.	r	l	yr	f	vgb		e		†																
Barnard (*Early Barnard*)	Ill.	r	ml	ry	f	vg		me		*		*				†										
Beers Smock	N. J.		ml	cwr	f	g	km			**	*	*				**		*		†						
Belle (*Belle of Georgia*)	Ga.	rob	ml	wr	f	vg	dkm	e		*	**	*	**		*											
Bequette Cling	Tex.	rov	ml	gwr	c	gvg	mk	me			*	†														
Bequette Free	Tex.	rov	ml	gwr	f	gvg	m	me		†	*	†														

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[a] The distinctive peculiarities of the families or strains of peaches known as Chinese, Persian, and Spanish being more or less ill defined and obscured by crossing or hybridization, a correct classification of varieties under these heads is not deemed practicable.

Section 9.—Nectarines and peaches—Continued.

SUBSECTION 2.—PEACHES—Continued.

Name.	Description.								Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Adhesion.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Bergen (*Bergen's Yellow*)	Amer.	r	vl	yr	f	vg		ml		*										*						
Bidwell Early (*Bidwell's Early*)	Fla.	ov	m	wr	c	g		ve						*												
Bidwell Late (*Bidwell's Late*)	Fla.	ov	l	wr	c	vg		l						*												
Bilyeu (*Bilyeu's Comet*)	Md.		vl	wr	f	g		vl			*	*														
Bishop (*Bishop's Early*)	Cal.	r	l	w	f	vg	m	ml			*	*				†										
Blood Cling (*Blood Clingstone*)	Amer.	rov	vl	yr	c	g		vl				*			**	*						†				
Blood Free (*Blood Freestone*)	Amer.	rov	l	yr	f	g		vl							*					†						
Bokhara (*Bokhara No. 3*)																*		*								
Brandywine (*Prize*)	Del.		l	y	f	g		l			*	*														
Brett (*Mrs. Brett*)	N. Y.	r	m	wr	f	g		vl																	*	
Brigdon (*Garfield*)	N. Y.	rov	m	cyr	f					*																
Briggs (*Briggs' May*)	Mass.	r	vl	wr	f	vg		em															*	*		
Cable (*Cable's Late*)	Ohio.	r	vl	yr	f	vg		ml				*		*	*	†				†						
California (*California Cling*)	Cal.	r	l	yr	c																		**			
Carman	Tex.	r	l	w		g		e		*		*	**	*	*	†						*				
Carpenter (*Carpenter Cling*)		obl	m	cwb	c	g									†	†										
Chairs (*Chairs' Choice*)	Md.	r	l	yr	f	g		m		*	**	*				*				†		**				
Champion	Ill.	r	ml	cyr	f	vg		em		**	**	**			**	**	*	*		*		†				
Charlotte (*Early Charlotte*)	Eur.	ov	l	gwr	f	vg		em															*			
Chili (*Hills' Chili*)	N. Y.	ov	m	yr	f	g		ml	*	*					*	*	*									
Chinese Cling (*China Cling*)	China.	r	l	cwr	c	vg		m			*	*	**	*	*	*				*		*				
Chinese Free		r	l	wr	f	gvg		m					*													
Climax (*Horn's Hybrid*)	Fla.	rov	m	yr	f	g		e						*												
Coleman		c	s	cwb	f	g		me							†											
Colon													**													
Columbia (*Indian Peach*)	N. J.	r	l	y	f	p	km	ml				†			*											
Conkling (*Conklin*)	Amer.	r	ml	ycr	f	g		m		*																
Connet (*Connet's Early*)	N. C.	obl	l	w	sc	vg	m	me			*	†														
Countess	Fla.	r	l	wr	f	g		m						*												
Crosby (*Frost Proof*)	Mass.	r	ml	gyr	f	g	dm	ml		**	*	*			*	**	*	**		*						
Delaware (*Delaware Rareripe*)	Del. ?	r	m	cwb	f	g		me		†																
Deming (*Deming's September*)		ob	l	yr	c			m				†	*													
Dewey (*Admiral Dewey*)	Ga.		m	y	f	g		e		*		†	*		*											
Dorothy														**												
Early China	Tex.	ov	m	w	f	vg		ve							*											
Early Crawford (*Crawford's Early*)	N. J.	rov	vl	yr	f	vg	dm	me	*	**	*	**	*		*	**		*		*		**	**	**	**	**
Early Michigan (*Husted No. 15*)	Mich. ?	r	m	gwb	sc	g				†																

Early York (*Early Purple*)	Eng.	rov	ml	gwr	f	vg	dm	e		*		*			*	*				*		†				
Eaton (*Eaton's Golden Cling*)	N. C.	r	ml	y	c	g		m					*							†						
Ede (*Captain Ede*)	Ill.	rov	m	yr	f			m								†										
Elberta	Ga.	robl	vl	yr	f	g	km	m		**	**	**	**	**	**	**		*		**		**	**	**	**	**
Emma	Ga.	re	vl	yr	f	vg	m	ml			*		*													
Emperor	N. J.		l	yr	f							†														
Engle (*Engle's Mammoth*)	Mich.?	r	l	yr	f	vg		ml		*																
Estella														*												
Everbearing	Ga.	obl	l	cw	f	g									†											
Excelsior (*Prince's Excelsior*)	N. Y.	rob	l	y	f	g		l			†															
Family Favorite	Tex.	obl	l	cr	f							†			**	†										
Fitzgerald	Can.	ov	l	yr	f	vg				*		†										†				
Florida (*Florida Crawford*)	Fla.	ovc	l	y	f	g		m						*												
Florida Gem	Fla.	r	m	w	f	g		e						**												
Foster	Mass.	r	vl	yr	f	vg		ml		*	*	*	*			*		**		*		**	**	**	**	**
Fox (*Fox Seedling*)	N. J.	r	m	wr	f	g		l		*	*															
Frances	Ohio	rov	l	yr	f			me			†	†												*		
Galveston														*	*											
George IV (*George the Fourth*)	N. Y.	r	l	wr	f	vgb	d	m																	**	
Gloire	Pa.	rov	vl	yr	f	vg	m	m		*	*	*				*		*		†		*	*			
Golden Cling	Cal.	ovc	vl	yr	c	vg	km	l								†						*		*		*
Gold Drop (*Golden Drop*)	Mich.?	rov	m	yr	f	vg				*																
Governor Hogg	Tex.?	r	l	cw	sc	gvg						†	*		†											
Greensboro	N. C.	r	m	yr	sc	g	m	e		*	**	**	**	**	*	*	*									
Hale Early (*Hale's Early*)	Ohio	r	m	gwr	sc	g	m	e		*		*	*					*		*		*	*	**	*	**
Hall (*Early Yellow Hall*)	Me.	r	l	yr		g		e						*												
Heath (*Heath Cling*)	Md.	rov	l	wr	c	vg	dm	l			*	**			*	*		*				**	**	**	**	**
Heath Free (*Freestone Heath*)	Mass.	obl	l	gw	f	g		ml				†								*						
Hiley (*Early Belle*)	Ga.	r	l	cwr	f			e		†		*	*		*											
Honey (*De Montigny*)	N. Y.	ov	s	cr	f	vg	dk	em						**	*											
Hynes (*Hynes' Surprise*)	Ky.	r	m	cw	sc	g	dm	l		*																
Imperial (*White Imperial*)	N. Y.	r	vl	wyr	f	vg		e						**												
Ingold (*Lady Ingold*)	N. C.	r	m	yr	f	vg	dm	em		*	*	*	†													
Iron Mountain	N. J.	robl	l	yg	sc	g				†																
Japan Dwarf (*Japan Dwarf Blood*)	Jap.	r	m	yr		vg		ve															*			
Jaques (*Jacques' Rareripe*)	Mass.	rc	l	yr	f	g		ml		†																
Jewel														**												
Kalamazoo	Mich.	ov	ml	yr	f	vg	dkm	me		**																
Kerr (*Jessie Kerr*)	Md.	ov	l	wr	f	g	m	ve							*	†										
Keyport (*Keyport Late*)	N. J.	rov	ml	wr	f	g	m	l								†										
Klondike	Pa.		l	wy		g		l			†															
[illegible]	N. J.	rob	l	gyr	f	vg		l																*		
Large York (*Large Early York*)	N. Y.	r	ml	wr	f	vg	dm	em		*		*														
Late Admirable (*Admirable*)	Fr.	rov	l	gr	f	vg	d	ml			*	†				†										
Late Crawford (*Crawford's Late*)	N. J.	rov	vl	yr	f	vgb	dm	l		*	**	**	*		*	**		*		**		**	**	**	**	**
Late Rareripe (*Prince's Late Rareripe*)	Amer.	rov	vl	yr	f	vg	dm	ml			*	*				*				†						
Lee (*General Lee*)	Amer.	rov	vl	gw	c	g	m	e			*	*	*		**					†						
Lemon Cling (*Kennedy's Carolina*)	S. C.	rov	vl	yr	c	vg	dm	m		*		*			*	*				†		†	*	**	**	*
Lemon Free (*Lemon Freestone*)	Ohio	rov	ml	yw	f	g	dm	em		*	*	*				†										
Levy (*Henrietta, Levy's Late*)	D. C.	r	l	y	c	vg	mk	vl			*	*			*	†		**						**	*	*
Lewis (*Lewis' Seedling*)	Mich.	r	ml	rw	f	vg	dkm	l		*																
Lola (*Miss Lola*)	Tex.	r	ml	rw	f	vg	dm	e				†			*											

Section 9.—Nectarines and peaches—Continued.

SUBSECTION 2.—PEACHES—Continued.

Name.	Description.								Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Adhesion.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Lone Tree	Iowa		ms	y	f	vg		ml								†	†									
Longhurst	Can.	ov	ml	y	f	g				†																
Lorentz	S. C.	r	ml	y	f	g						†														
Louise (*Early Louise*)	Eng.	r	m	r	f	vg		e			*	†														
Louisiana		r	l	w	f										†											
Lovell	Cal.	r	l	y	f	vg	km	l															*	**	*	**
Lovell (*Lovell's White*)	Cal.		vl	yr	c					†																
McDevitt (*McDevitt Cling*)	Cal.	obc	vl	yr	c	vg	km	m				†										†		*		
McIntosh		r	l	cw	sc	vg		me				†														
McKevitt (*McKevitt's Cling*)	Cal.			w	c																			*		
Maggie (*Maggie Burt*)	Tex.	ov	l	w	c	g		ve						**												
Mamie Ross	Tex.	rov	ml	wr	sc	g	dm	e			*	†	*	**	*											
Mary (*Mary's Choice*)	N. J.? Mass.?	obl	l	y	f	vg	m	l			*												*	**	*	*
Mathews (*Mathews' Beauty*)		r	l	y	f	g							†		*											
Mayflower													†		*											
Miller (*Miller Cling*)			vl	y	c							†	*													
Morris White (*Morris White Rareripe*)	Amer.	ov	l	gw	f	vg	km	m		*		*				†						†				
Mountain Rose	N. J.	r	l	wr	f	vg	dm	em		**	**	**	**		**	**		*		**		*				
Muir	Cal.	rov	lvl	y	f	vg	dkm	m														**	**	**	**	**
New Prolific		rov	l	y	f	vg				†																
Niagara	N. Y.		l		f	vg		me			†															
Nichols (*Nichols' Orange*)	Cal.?		l	y	c																			**	**	**
Oldmixon Cling (*Oldmixon*)	Amer.	rov	l	cwr	c	vgb	dk	m		*	*	*			*	*		*		*						
Oldmixon Free (*Oldmixon*)	Amer.	rov	l	cwr	f	vg	dk	m		**	**	*	*		**	*		*		*						
Onderdonk (*Onderdonk's Favorite*)	Tex.	ov	ml	w	f	vg	dm	m						*	*							*				
Orange Cling (*Orange Clingstone*)		r	vl	yr	c	g	km	ml															*	**	**	**
Orman	Tex.?													*												
Ovieda	Fla.?	c	m	gwb	f	vg		me						*												
Pallas (*Honeydew*)	Ga.	ov	ml	w	f	vg	dm	e						*	*											
Parham (*Lady Parham*)	Miss.?	r	l	yw	f	g	km	l							*											
Parks (*Parks' Late Cling*)	Ill.	rob	vl	cyr	c	g		vl								†										
Peento (*Chinese Flat*)	Ga.	f	sm	cwr	f	g	dm	ve						*												
Peninsula (*Peninsula Yellow*)	Md.	rov	l	y	f	g	m	ml			†															
Phillips (*Phillips' Cling*)	Cal.	ovc	l	y	c	vg	dm	ml															**	**	**	**
Picquet (*Picquet's Late*)	Ga.	r	vl	yr	f	vg	d	l			*	*	*		*	*				†				*		
Prize		r	l	y	f	vg	m	l			*															
Ray	Miss.	r	m	cwr				em			†	†	*													

Red Cheek (*Red Cheek Melocoton*)	Amer.	rov	l	yr	f	g	dm	m		*	*					†										
Red River	Tex.	r	ml	cw	sc	gvg		e				†	*													
Reeves (*Reeves' Favorite*)	N. J.	rov	l	yr	f	g	m	m		**	*	*				*				†		*				
Richmond	N. Y.	r	l	yr	f	g	m	m		*										*						
Rivers (*Early Rivers*)	Eng.	r	ml	cwr	f	g	dm	e		*	*	*	*		**	*				†						
Robert	Del.?	r	m	y	f	vg						†														
Royal George (*Early Royal George*)	Eur.	r	ml	wr	f	b	d	me		*	*	*				†				†						
Rupely (*Ruply*)	Tex.?													†												
Russell (*Russell No. 1*)	Nebr.	r	l	wr	f	vg	dkm	e								*	*									
St. John (*Yellow St. John*)	Miss.	r	ml	yr	f	g	m	e		**	*	*	*		*	*		*				*	*	**	*	**
Salway	Eng.	rob	l	yr	f	g	m	l		**	*	**			*	**		**		*		*	*	**	**	**
Sellers (*Sellers' Golden Cling*)	Cal.		vl	y	c			l														*	*	**	**	**
Slappey		r	m	y	f	vg		e				†			†											
Smock (*Smock's Free*)	N. J.	ov	l	y	f	g	m	l		**	**	*			*	**				*		†				*
Sneed (*Peeble's May Cling*)	Tenn.	ov	ml	gw	c	g	m	ve		*		*	*	*	*	*				†						
Snow	Amer.	r	l	w	f	g	dm	m		*		*				*				†						
Stevens (*Stevens' Rareripe*)	N. J.	rov	m	cw	f	g	m	ml		**	*	*				*		*								
Stinson (*Stinson's October, Stinson's Late*)	Miss.?	rov	l	cwr	c	g		l							†											
Stonewall (*Stonewall Jackson*)	Tex.	rob	l	gy	c	g	km	e				†	*													
Strawberry (*Rose*)	N. J.	ov	m	r	f	vg	dm	em												†					*	*
Stump (*Stump the World*)	N. Y.	rob	vl	wr	f	g	m	ml		*	**	**	*		*	**		*		†		†				*
Suber	Fla.?	r	m	cwr	c	g		e						**												
Success	Tex.	r	l	y	f	g				†																
Superb			l									†														
Susquehanna (*Griffith Mammoth*)	Pa.	r	l	yr	f	vg	dkm	m			*	*	*			*						†	**	**	**	**
Taber	Fla.?	r	m	cwb	c	gvg		m						*												
Tarbell	Mass.	r	vl	yr	f	vg		ml							*											
Taylor	D. C.	r	l	y	c	vg									†											
Texas (*Texas King*)	Tex.	ro	m	yg	sc	g	d	l				†	*	*	*											
Thompson (*Mrs. Thompson's Golden Free*)	Fla.	b		y	f										†											
Thurber	Ga.	robl	l	wr	f	vg	d	e			*	†	**		*	†				†						
Tillotson (*Early Tillotson*)	N. Y.	r	m	wr	f	vg	d	e		*		*	**			†				†						
Tippecanoe (*Hero of Tippecanoe*)	Pa.	r	vl	yr	c	vg	dm	l				†								†						
Toledo (*Early Toledo*)	Ohio?	r	l	yw	f	g		e		*																
Triana														**												
Triumph	Ga.	r	ml	yr	f	g	dm	e		*	*	*		*	*	*		*				*	**	*	*	*
Troth (*Troth's Early Rareripe*)	N. J.	rov	m	wr	f	g	m	me			*															
Tuskena (*Tuscan Cling*)	Miss.	robl	m	yr	c	g	dkm	m														*	**	**	**	**
Victor		r	m	cw	sc	g		e				†	*	*	†											
Victoria (*Early Victoria*)	Eng.	r	m	yr	f	vg		e							†											
Waddell		obl	ml	cw	f	g				*		*	**													
Wager	N. Y.	obl	m	yr	f	g	m	m		*					*	*						*		*		
Waldo	Fla.	ov	m	w	f	g	dm	e						**	*											
Walker (*Walker's Variegated Free*)	Del.	rov	vl	w	f	vg	dm			*	*															
Ward (*Ward's Late Free*)	Amer.	rov	l	wr	f	vg	dk	vl		*	*					†										
Waterloo	N. Y.	r	m	wr	sc	g	dk	m		*		*				†				†		†				
Wheatland	N. Y.	r	vl	yr	f	g	dm	m		*	*					†				†		*	*			*
Wonderful	N. J.	r	l	yr	f			l		†		†						*								
Yazoo (*Yazoo Cling*)	Miss.				c										†											
Yellow Rareripe	Amer.	r	l	yr	f	vg	dm	em		*		*								†						
Zell													*													

Section 10.—PEARS (*Pyrus communis* and *P. sinensis*).

[KEY.—*Origin:* Amer., America; Belg., Belgium; Eng., England; Fl., Flanders; For., Foreign; Fr., France; Hol., Holland; Rus., Russia, etc. *Form:* i, irregular; o, oblate; obl, oblong; obo, obovate; obt, obtuse; ov, ovate; p, pyriform; r, round; t, turbinate. *Size:* l, large; m, medium; s, small; v, very. *Color:* b, brown; c, crimson; g, green; r, red; ru, russet; w, white; y, yellow. *Quality:* b, best; g, good; p, poor; v, very. *Use:* d, dessert; k, kitchen; m, market. *Season:* e, early; l, late; m, medium; v, very.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Ananas d'Ete (*Summer Pineapple*)	Hol.	obtp	l	ybru	vg	dm	me		*																
Angouleme (*Duchesse d'Angouleme*)	Fr.	obtp	vl	gyru	vg	dkm	m	*	**	**	**	*		*	*	*	*		*		*	*		*	
Anjou (*Beurre d'Anjou*)	Fr.	oblp	l	gyru	vg	dm	ml	*	**	**	*				**	**	*		**		**	*	*		
Ansault (*Bonne de Puits-Ansault*)	Fr.	robtp	ms	gyru	vg	d	me	*	*																
Archangel (*St. Michael Archangel*)	Fr.	obop	l	yru	gvg	dm	m		*	*	*														
Bartlett (*Williams Bon Chretien*)	Eng.	oblp	l	yru	vg	dkm	m	*	**	**	**	**		**	**	*	**		**		**	**	**	**	**
Bessemianka	Rus.	robo	m	gyru	g	km	me	**											†						
Bloodgood (*Early Beurre*)	N.Y.?	obtp	m	yru	vg	dm	e		*		†				*	**			†						
Bordeaux (*Duchesse de Bordeaux*)	Fr.	robt	m	yru	g	dkm	vl		*										†						
Bosc (*Beurre Bosc*)	Belg.	oblp	l	ycru	vgb	d	ml		*	**	*											*			
Boussock (*Doyenne Boussock*)	Belg.	obtp	l	yru	vg	dm	me		*	*	*								†						
Brandywine	Pa.	p	m	gyru	gvg	dm	me		*	*	†								†		*				
Buffum	R. I.	obtp	ms	ycru	vg	dk	m		*	*	*				*				†						
Chambers (*Early Harvest of Kentucky*)	Md.? Ky.?	robo	m	yr	g	km	ve		*		†														
Clairgeau (*Beurre Clairgeau*)	Fr.	p	l	yrub	g	km	ml		*	*	*	*			*		*		*		*	**	*		
Clapp Favorite (*Clapp's Favorite*)	Mass.	obtp	l	yrb	g	km	m	**	**	*	*				*	*			*		**	**	**	**	**
Columbia (*Columbia Virgalicu*)	N. Y.	obo	l	gy	g	km	l		*						†				*						
Comice (*Doyenne de Comice*)	Fr.	rop	l	gyru	vgb	dm	ml		*	*									†		*	**	**	**	**
Danas Hovey (*Dana Hovey*)	Mass.	obtp	s	gyru	vgb	d	l		*	*	*														
Diel (*Beurre Diel*)	Belg.	obtp	l	gbru	vg	dm	l		*		†								†						
Drouard (*President Drouard*)	For.	obop	l	gyru	gvg	dm	m	*	*																
Dunmore	Eng.	oblp	l	grru	vg	dm	me															*			
Easter Beurre (*Beurre Easter*)	Fl.	robt	l	gyru	vg	dm	vl		*	*											*	**	**	**	**
Elizabeth (*Manning's Elizabeth*)	Belg.	obtp	ms	yr	vgb	d	me		*	*	†														
Fertility		oblov	m	yb	p	m	m							†											
Flemish (*Flemish Beauty*)	Belg.	obtp	l	yrb	vg	dm	me	*	*	*	*				*	**	*		*		**	**			*
Fluke															†	*									
Fred. Clapp (*Frederick Clapp*)	Mass.	robtp	ml	y	g	km	m		*										*						
Garber (*Garber's Hybrid*)	Pa.	robtp	l	y	p	km	m			*	*	*	**	*	*		**		*						
Ghislain (*Saint Ghislain*)	Belg.	p	m	y	gvg	dm	m	*																	
Giffard (*Beurre Giffard*)	Fr.	p	m	gyr	vg	dm	e	*	*	*	†	*													
Glout Morceau	Fl.	ovobtp	l	gyb	vg	dm	l		*														**	**	*
Golden Russet (*Japan Golden Russet*)	Jap.	robt	l	cru	p	km	ml							*											
Goodale (*Goodale's Seedling*)	Me.	oblp	l	ycru	vg	dm	m	*	*																
Grand Isle	Vt.	robt	m	y	vg	dm	m	*	*																
Gray Doyenne	For.	obtp	m	cru	vgb	dm	m		*	*															
Hardy (*Beurre Hardy*)		obtp	l	grub	vg	dm	m		*												†		*		*
Heyst (*Emile d'Heyst*)	Belg.	oblp	l	ybru	vgb	d	l		*																

Howell (*Howell's Seedling*)	Conn.	rp	l	y	vg	dm	m		*	*	*				*						†				
Idaho (*Mulky*)	Idaho	r	l	y	vg	m	ml										†				*				
Kieffer (*Kieffer's Hybrid*)	Pa.	rp	ml	yrub	p	km	ml	†	*	*	**	**	**	**	**	**	**		*		**				
Kirtland (*Kirtland's Seckel*)	Ohio	obtp	ms	yeru	vg	d	me		*										†						
King Karl (*Konig Karl Von Wurtemberg*)		obtp	l	yrb	g	km	l				†				†										
Koonce	Ill.	p	m	gyb	g?		e				†			*											
La Motte (*Bezi de la Motte, Crassane Bergamot*)		robp	m	ygru	vg	dm	m			*	*				†	*									
Lawrence	N. Y.	obop	m	yru	vgb	dm	l	*	**	*	*				*						*	**			
Lawson (*Comet*)	N. Y.	obtp	ml	ybr	g	m	ve																*	*	*
Le Conte (*Chinese Pear*)		oblp	l	y	p	km	ml			*	*	**	**	**					†						
Lincoln (Ill.)	Ill.	oblp	l	gy	gvg		m				†				†										
Longworth (*Longworth's No. 1*)	Iowa	obtov	m	gy	g		m								†	*									
Louise (*Louise Bonne de Jersey*)	Fr.	oblp	m	gybr	vg	dm	m		**	*	*						*		**		†	*			
Lucrative (*Belle Lucrative*)	Fl.	obtp	m	ygru	vgb	d	me		*	*	†								*						
McLaughlin	Me.	obtp	ml	gyru	gvg	dm	l		*																
Madeleine (*Citron de Carmes*)	Fr.?	obop	ms	ygbru	gvg	dm	ve		*										†		†				*
Magnolia	Ga.	robtp	ml	ru	p	km	e				†		*	*											
Malines (*Josephine de Malines*)	Belg.	robt	m	gyru	vg	dm	l	*	*										†						
Marguerite (*Petite Marguerite*)	Fr.	obtp	s	ybru	vg	d	me	†	*										*		†				
Marie Louise (*Maria Louise*)	Belg.	oblp	ml	gyru	vg	dm	l		*																
Merriam	Mass.	robtp	m	yru	vg	dm	m		*																
Mount Vernon (*Walker's Seedling*)	Mass.	robtp	ml	yeru	vg	dm	l	*	*		†						*		†		†				
Napoleon (*Beurre Napoleon*)	Belg.	obtp	ml	gy	g	dm	me		*	*															
Onondaga (*Swan's Orange*)	Conn.?	ovp	l	yru	gvg	km	m		*	**	†											*			
Osband (*Osband's Summer*)	N. Y.	robo	s	yru	vg	d	me		*	*	*														
Ott	Pa.	robo	s	gyru	vg	d	me			*															
Paradise (*Paradise d' Automne*)	Belg.	oblp	ml	yeru	vg	dm	m		*	*															
P. Barry (*Barry*)	Cal.	oblp	l	cru	vg	dm	l												*		*	*	**	**	**
Philopena (*Philopoena*)	Ind.	oblp	ms	cgru	vgb	d	ml				†														
Platt (*Platt's Seedling*)	N. Y.	robtp	m	yru	g	dm	m	†																	
Rostiezer	Eur.	roblp	ms	ygru	vgb	d	me		*																
Rutter	Pa.	rp	ml	gyru	vg	dm	ml		*	†	†				†				*						
Seckel (*Seckle*)	Pa.	rp	s	cybru	b	d	ml		**	**	**	*			**	**	**		**		**	**	**	**	**
Sheldon (*Black Vangalien*)	N. Y.	robt	ml	geru	vgb	dm	ml	*	**	*	*				*		*		*		**	*			
Souvenir (*Souvenir du Congress*)	Fr.	oblp	lvl	yeru	vg	dm	me		*		†								*						
Sterling	N. Y.	rop	m	yeru	gvg	dm	m		*																
Stevens (*Stevens' Genesee*)	N. Y.	r	l	y	vg	dm	me		*	*															
Summer Doyenne (*Doyenne d' Ete*)	Belg.	robop	s	yrru	gvg	d	ve		*	†	*	*							*		**			**	*
Superfin (*Beurre Superfin*)	Fr.	rp	ml	yeru	vgb	dm	m		*										†						
Texas (*Texas Ironclad*)	Tex.?	p	ml	wy	g		m						†												
Tyson	Pa.	oblp	ms	yeru	vgb	dm	me		*	*	**				*		*								
Urbaniste	Fl.	obop	ml	yru	vg	dm	ml	*	*	*	†								*						
Vermont Beauty	Vt.	oblp	m	yeru	vg	d	m	**	*																
Vicar (*Vicar of Winkfield*)	Fr.	oblp	l	gyb	g	km	ml		*		*				*				*		†				
Warner (*Warner's Seedling*)	Ind.		m		g		m								†	†									
Washington (*Naaman's Creek*)	Del.	ov	m	y	vg	m	me			*															
White Doyenne (*Fall Butter*)	Fr.	obo	ml	wyr	vgb	dm	ml		*		*				†		*		*		*	**			
Wilder Early (*Wilder's Early*)	N. Y.	p	ms	ybr	vg	dm	me	**	*		*				†				*			**			
Winter Bartlett (*Late Bartlett*)	Oreg.	oblp	l	y	vg	m	l							†					*		†	**			*
Winter Nelis (*Nelis d' Hiver*)	Fl.	robo	m	ygru	vgb	dm	l	*	**	*	*								**		**	**	**	**	**
Worden (*Worden's Seckel*)	N. Y.	obtp	m	ybr	vg	dm	me									†									

Section 11.—PLUMS (*Prunus*).

[KEY.—*Origin:* Amer., America; Belg., Belgium; Eng., England; Fr., France; Ger., Germany; Jap., Japan; Ont., Ontario; Rus., Russia, etc. *Form:* c, compressed; f, flattened; ob, obovate; obl, oblong; ov, oval; r, round. *Size:* l, large; m, medium, s, small; v, very. *Color:* b, black; br, brown; g, green; p, purple; r, red; v, violet; w, white; y, yellow. *Adhesion:* c, cling; f, free; sc, semicling. *Quality:* b, best; g, good; p, poor; v, very. *Use:* c, curing; d, dessert; k, kitchen; m, market. *Season:* e, early; l, late; m, medium; v, very.]

SUBSECTION 1.—PRUNUS AMERICANA.

Name.	Description.								Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Adhesion.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Advance	Nebr.	ov	lvl	yr	c	g	km	ml							†											
Aitkin (*Itasca*)	Minn.	ovf	l	y	c	g	dkm	me		*						*	†				†	†				
American Eagle (*Eagle*)	Mo.	rov	ml	r	c	g	m	me								†	*			*						
Blackhawk	Iowa	c	l	r	f	vg	dm	ml								*						†				
Brittlewood	Nebr.	rov	l	r	sc	g	m									**	**									
Cheney		ov	l	pr	c	vg	dm	e		†						*	*				†					
Comfort	Iowa	ov	vs	r	sc	g	d	m														†				
Cottrell	Minn.	robl	l	yr	c	g	km	me														†				
De Soto	Wis.	ovc	m	yr	c	vg	km	m								*	**	*		†	**					
Forest Garden	Iowa	r	l	pr	c	gvg	k	me	*							**	**	*		**						
Free Silver	Iowa	ovc	l	r	c	g	k	m							†											
Gaylord	Iowa	ov	l	pr	c	gvg	dkm	me								†	*									
Hammer	Iowa	rov	ml	r	f	vg	km	ml								**	*									
Hawkeye	Iowa	rov	l	yr	c	g	km	ml	*							**	*			*						
Louisa	Mo.	ov	m	r	c	g	m	ml			*															
New Ulm	Minn.	ov	l	yr	c	g	dk	l									**									
Ocheeda	Minn.	ov	m	yr	c	vg	dk	m								*	**									
Piper (*Piper's Peach*)	Minn.	r	ml	r		vg	dk	l									*									
Quaker	Iowa	rov	lvl	r	sc	vg	dk	me								†	*									
Rockford	Iowa?	rov	ml	r	c	vg	dk	me	*							†	†			*						
Rollingstone	Minn.	rov	ml	r	c	vg	dk	m								†	*			*						
Stella	Nebr.		l			vg		ve		†																
Stoddard	Iowa	ov	l	yr	c	g	dk	me	†	*	*	†				**	**	*								
Surprise	Minn.	ov	ml	r	c	vgb	dm	m									**				†					
Terry	Iowa		ml	yr	c			e	†								**									
Weaver	Iowa	ovc	l	yr	sc	g	km	m	*	†		*			*	*	**	*		*						
Wolf	Iowa	rov	ml	yr	f	g	km	m	**	*		*				**	**	*		*	*					
Wonder (*Nebraska Wonder*)	Nebr.	r	l	gwy		vg	dm	e							†											
Wyant	Iowa	ovc	ml	yr	c	g	k	m	*	†		†				**	**	*		*	*					

SUBSECTION 2.—PRUNUS ANGUSTIFOLIA.

Caddo Chief	La.	ov	s	r	c	p	m	ve				†		*		†				†						
Cluck	Tex.	ov	m	r	c	g	m	l			†															
Lone Star	Tex.	ov	ms	r	c	g	k	m			*															
McCartney	Tex.	r	ml	y	c	vg	dkm	e							†			†								
Munson	Tex.	obl	ml	r	c	g	dm	me			*	†	*													
Newman	Ky.	rc	ml	yr	c	g	m	ml			*					*										
Pottawattomie	Tenn.	obl	ml	r	c	g	km	ml								*	*	†		*						
Yellow Transparent (*Transparent*)	Tex.	obl	ml	y	c	g	km	me				*				*										

SUBSECTION 3.—PRUNUS CERASIFERA.[a]

De Caradeuc	S. C.	r	m	r	c	p	k	e				†	*													
Marianna	Tex.	r	ml	r	c	g	km	l							**	*										

[a] Includes supposed hybrids.

SUBSECTION 4.—PRUNUS DOMESTICA.

Agen (*French Prune, Petite Prune*)	Fr.	ov	ms	rp	f	vgb	cdm	l		*												**	**	**	**	**
Archduke	Eur.	ov	l	b	c	g	km	ml		*		*								*						
Arctic (*Moore's Arctic*)	Me.?	rov	ms	b	sc	g	dk	m	**	*		*						*		**						
Bavay (*Reine Claude de Bavay*)	Eur.	r	m	yg	f	b	d	ml	*	**	*	*				*	*	*		*			*			
Bradshaw (*Blue Imperial, Niagara?*)	Amer.	ovr	ml	pr	f	g	dm	m	**	**	*	*						*		**		**	**	*		
Clyman	Cal.	r	m	pr	f	g	dm	e		*	*									*				**	**	*
Columbia	N. Y.	r	m	byp	f	g	dk	ml		*		*								*		**	**	*		
Damson	Eur.	ov	s	b	f	g	km	ml	**	*		*				**		*		*		*	*	*	*	*
Diamond (*Black Diamond*)	Eng.	ov	ml	b	c	g	km	m		*						†	†							**		
Duane (*Duane's Purple*)	N. Y.	ov	lvl	rp	c	g	km	e		*										*					*	
Emigrant	Kans.	ov	vl	p		g	km	m												†						
Englebert (*Prince Englebert*)	Belg.	ov	m	bp	f	g	km	m	†											†						
German (*German Prune*)	Ger.	ov	sm	bp	f	g	ckm	m	*			*						*		**		**	**	**	**	**
Giant (*Giant Prune*)	Cal.	robl	vl	rp	f	g	cm	m												*		*	**	**	**	**
Glass (*Glass Seedling*)	Ont.	rov	m	rp	c	g	m	m	*																	
Golden Drop (*Coe's Golden Drop*)	Eng.	ov	lvl	y	sc	g	cdm	m	*			*						*		*		*	**	**	*	*
Golden Prune	Oreg.	oblov	l	gy	f	g	dc	m														*	**	**		
Grand Duke	Eur.?	ov	lvl	b	c	g	km	l				†										*		**	**	*
Green Gage	Fr.	ov	m	gy	sc	b	d	m	*									*		**		*	**	*	**	**
Gueii (*Blue Magnum Bonum*)	N. Y.	ov	m	bp	c	g	m	m	*			*														
Hand (*General Hand*)	Pa.?	r	ml	gy	c	vg	m	ml			*	*														
Hudson (*Hudson River Purple Egg*)	N. Y.?	oblov	l	rp	c	g	dm	m								*				*						
Hulings (*Hulings' Superb*)	Pa.	rov	vl	gy	c	g	k	m			*	†				*										
Imperial Gage (*Prince's Imperial Gage*)	N. Y.	rov	m	yg	f	vgb	dm	m			*	*				*				*		*	**	**	*	**
Italian Prune (*Fellenberg*)	Eur.	oblov	ml	pb	f	vg	cm	l				*				*		*		*		**	**	**	*	*

Section 11.—Plums—Continued.

SUBSECTION 4.—PRUNUS DOMESTICA—Continued.

Name.	Description.								Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Adhesion.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Jefferson	N. Y.	rov	ml	gy	f	vgb	dm	ml				*								†		*	*	**	*	**
Lombard	N. Y.	rov	ml	rv	c	g	km	me	**			*				**	**	*		**		†				
McLaughlin	Me.	r	m	gy	c	vg	dm	m	*																	
Moldavka	Rus.	oblov	ml	y	f	g	m	me									*									
Monarch	Eng.	rov	l	rp	f	g	dkm	l	†			†														
Monroe (*Monroe Egg*)	N. Y.	rov	ms	y	f	vgb	d	m												†						
Niagara [Probably identical with Bradshaw]	Amer.	rov	ml	pr	f	g	dm	m										*								
Orleans (*Smith's Orleans*)	Eng.	ov	lvl	rp	c	gvg	m	m	*	†						*				†						
Peach	Amer.	r	vl	br	f	vg	km	ve	*											*		**	**	**		
Pond (*Pond's Seedling, Fonthill, Hungarian Prune*)	Eng.	ov	vl	yrv		g	dm	m	*									*		*		**	**	**	**	**
Pride (*Shipper's Pride*)		r	l	p		g	km	l		*										†						
Prince (*Prince's Yellow Gage*)	N. Y.	ov	l	y		vgb	dm	e	*		*									†						
Purple Favorite	Amer.?	r	ml	yp	f	vgb	dm	e												†						
Purple Gage (*Reine Claude Violet*)	Eur.	r	m	vb	f	vg	dk	m												†						
Quackenboss	N. Y.	rov	ml	pv	c	g	m	m				*								*						
Raynes	Que.								†																	
Richland	Pa.	ov	l	b	c	g	km	m			*	*								†						
Royal Hative	Fr.	r	m	p	f	vg	k	e												†		†		*		
St. Ann (*Bonne St. Ann*)	Vt.			b		vg	dm		*																	
Saratoga	N. Y.	rov	l	pr	c	g	m	e		*										†						
Saunders	Ont.	rov	l	gy		g	km	m		*																
Sergeant (*Robe de Sergeant*)	Eur.	ov	m	b	sc	vg	cm	m														†		**	*	**
Sharp (*Sharp's Emperor, Victoria*)	Eng.	ov	lvl	r	f	vg		m		*																
Shropshire (*Shropshire Damson*)	Eng.	ov	s	b	c	g	km	m		**	*	*				**		**		**						
Spaulding	Pa.	ov	m	yg		g	m	m	*																	
Splendor		oblov	l	rp	f	vg		me															*	**	†	*
Sugar	Cal.	ovf	l	gp	f	vg	cdm	ve														**	**	**	**	**
Tennant	Wash.		l	bp			c															†	**	*		
Tragedy	Cal.	ov	ml	b	c	g	m	e												*		*		**	**	**
Transparent (*Transparent Gage*)	Fr.	rob	m	gyr		vg	dk	m	*											†						
Wales (*Prince of Wales*)	Eng.	robl	l	rp	f	g	m	me		†										†						
Wangenheim	Ger.	ov	m	p	f	vg	m	me			*	†				†						*				
Washington (*Bolmer*)	N. Y.	r	ml	gy	f	vg	dm	me	*	*	*	†				*		*		†		†	**	**	*	**
Willamette	Oreg.	ov	ml	rbr		vg	dm	me														**	*			
Yellow Egg (*Dame Aubert*)	Eur.	ov	vl	gy		vg	ck	m	*	**		*				*		*		*		*	**	**	**	**

SUBSECTION 5.—PRUNUS HORTULANA.

MINER GROUP.																										
151 Miner (*Parsons*)	Tenn.	robl	ms	rp	c	g	km	ml			*	*				**	**	*		*						
Prairie Flower	Mo.?	rov	ml	yr	c	vg	m	ml			*															
WAYLAND GROUP.																										
Benson	Nebr.	ov	m	r	c	g	km	ml			†															
Cumberland	Tenn.	obl	l	y	c	g	km	l				[illegible]				*				†						
Golden Beauty	Tex.	r	ml	y	c	vgb	dkm	ml			†	[illegible]	[illegible]			*				[illegible]						
Moreman	Ky.	r	s	r	c	g	km	l			*															
Reed	N. J.	r	ms	r	sc	g	dkm	l			*	†														
Terrell	Tex.?													*												
Wayland	Ky.	r	ml	r	c	g						†				†										
WILDGOOSE GROUP.																										
Choptank	Md.	ov	ml	r	c	g	m	me			[illegible]	†														
Clifford (*Mrs. Clifford*)	Tex.	ov	l	r	sc	g	m	m				†	[illegible]			[illegible]										
Downing (*Charles Downing*)	Iowa.	rov	l	r	c	vg	dm	l		†	[illegible]	*								†						
Dunlap (*Dunlap No. 2*)	Nebr.	ov	l	r	c	g	m	me			*	*														
Indian Chief	Tex.?	ov	m	r	c	p	m	me				*								†						
Kroh (*Poole, Poole's Pride*)		ov	sm	yp	c	g									*	*										
Milton	Iowa.	ov	ml	r	c	g	m	ve			[illegible]	[illegible]	[illegible]			[illegible]										
Roulette	Tex.?	ov	ml	r	c	g	m	m			†															
Smiley	Ala.?	ov	m	r	c	g	m	ml																		
Sophie	Md.	obl	ml	r	c	g	km	m			†					[illegible]										
Whitaker	Tex.	ov	m	r	c	g	km	m			[illegible]	*														
Wildgoose	Tenn.	ov	ml	r	c	g	km	m		†	**	**	**		[illegible]	**	**	**		[illegible]						
Wooten	Tex.	obl	l	r	c	g	km	ml			†				*											

SUBSECTION 6.—PRUNUS TRIFLORA, INCLUDING HYBRIDS.

Abundance (*Botan*)	Jap.	rov	ml	br	c	g	km	me	*	**	**	**	**	**	**	*	†	**		*						
Bartlett	Cal.?	ov	m	r		vg						†														
Burbank	Jap.	rc	l	rp	c	g	km	ml	*	**	*	*	*	*	**	**	†	**		*		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Chabot (*Yellow Japan*)	Jap.	rov	l	rp	c	g	km	me	*	*	*	*	*							*		†		[illegible]		
Chalco	Cal.	rob	l	r	f	vg						†														
Climax (*Royal* of Van Deman)	Cal.	rc	vl	r	f	vg	dm	ve				†												[illegible]	[illegible]	[illegible]
Combination	Cal.?	r	m	y	c	g		e																	†	
Excelsior	Fla.	r	m	rp		g	dm	e			*		*	*												
Georgeson	Jap.	rov	l	y	c	vg	km	e	†			†														
Golden (*Gold* of Stark Bros.)	Cal.	rob	ml	y	c	g	dm	ve				†			*	†		[illegible]								
Gonzales	Tex.	r	l	yr	c	vg							†		*			†								
Hale (*Prolific* of Burbank)	Cal.	r	l	r	c	vg	dm	ml																		[illegible]
Hattankio (*Hattan, Hytankio*)	Jap.	rc	l	y	sc	gvg		e							†											
Kelsey	Jap.	rov	vl	gy	sc	vg	dkm	l					*	*										[illegible]	[illegible]	[illegible]

Subsection 11.—Plums—Continued.

SUBSECTION 6.—PRUNUS TRIFLORA, INCLUDING HYBRIDS—Continued.

Name.	Description.								Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Adhesion.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Kerr	Jap.	ov	l	y	c	g	km	m				†	*													
Maynard	Cal.	ov	vl	r	f	vg	dkm																*			
Normand	Jap.	r	ml	r		vg	dm	ve					*													
Occident (*Sultan* of Burbank)	Cal.	r	vl	gr	f	vg							*													
Ogon	Jap.	r	ml	y	f	g	km	e			†	†	*			†										
Red June (*Red Nagate, Shiro-Smomo*)	Jap.	ov	m	r	sc	g	km	ve	†		**	**	**		*	*	*	*		†	*					
Red May	Tex.	obl	ml	r				ve							*											
Santa Rosa	Cal.?	rc	ml	r		vg									†											
Satsuma (*Blood*)	Jap.	r	ml	p	c	vg	km	ml		*	†	*			*	*		*		*		†		**	*	**
Simon [a]	China.	r	l	p		p	m	e																*	*	*
Wickson	Cal.	r	vl	rp		vg	m	m		†		*	*		*			*				*	*	**	**	**
Willard (*Botan No. 26*)	Jap.	rov	s	r	f	p	m	m		†	*	†				†				†						

[a] Belongs to species *Prunus simonii*.

Section 12.– QUINCES (*Cydonia*).

[KEY.—*Origin:* Amer., America; Fr., France, etc. *Form:* ob, oblate; obt, obtuse; p, pyriform; r, round. *Size:* l, large; m, medium; s, small; v, very. *Color:* g, green; o, orange; y, yellow. *Quality:* b, best; g, good; p, poor; v, very. *Use:* k, kitchen; m, market. *Season:* e, early; l, late; m, medium; v, very.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Angers	Fr.			gy							†	*													
Bourgeat										†	†														
Champion	Conn.		l	gy	g		l		**	*	*				**				*						
Chinese (*Sinensis*)	China.	obtp	vl	y			vl					*	**	*											
Fuller		p	l	y	g				*																
Meech (*Meech's Prolific*)	Conn.	rob	l	oy	g	km	m		†	*	*				**				†		*				*
Missouri (*Missouri Mammoth*)		rob	vl	oy	vg	km	me		†	†	*				**				*		*				
Orange (*Apple-Shaped*)	Amer.	rob	vl	oy	vg	km	e	*	**	**	**	**			**				*		*				*
Pear (*Pear-Shaped*)	Amer.	obtp	l	y	g	km	me		*		†												**		
Rea (*Van Slyke*)	N. Y.	rob	vl	oy	vg	km	me		*	*	*	*			†				†						
Van Deman	Cal.		vl		vg	km	e								†										

Section 13.—RASPBERRIES (*Rubus*).

[Key. *Origin:* Eng., England; Eur., Europe; Fr., France; Ont., Ontario, etc. *Form:* c, conical; ob, obtuse; r, round. *Size:* l, large; m, medium; s, small; v, very. *Color:* b, black; c, crimson; p, pale; pu, purple; r, red; y, yellow. *Quality:* b, best; g, good; p, poor; v, very. *Use:* d, dessert; k, kitchen; m, market. *Season:* e, early; l, late; m, medium.]

Subsection 1.—RUBUS IDAEUS.[a]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Clarke	Conn.	rc	ml	r	vg	dm	me	*							*		*								
Fastolf (*Filby*)	Eng.	rc	vl	cr	vg	d	m	*	*										†						
Franconia (*Naomi*)	Fr. ?	rc	l	pr	vg	m	me	*	*										†						
Hudson River (*Hudson River Antwerp*)	Eng.	c	l	r	vg	m	m	*											†						
Orange (*Brinckle's Orange*)	Pa.	rc	l	y	vgb	d	ml	*	*						*										
Red Antwerp (*Old Red Antwerp*)	Eur.	rc	l	r	vgb	dm	m			*					*		*		†		†	**	*		
Superlative	Cal. ?	c	l	yr																				†	
Vermont	Vt.	rc	m	y	vg	dk	l	**	*																

[a] Includes possible hybrids.

Subsection 2.—RUBUS NEGLECTUS.

Name.	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Cardinal	Kans.	r	l	r	g	dk	m				†			*	*	*	*								
Caroline	N. Y.	rob	m	y	g	km	e				†				*				†						
Columbian	N. Y.	r	vl	pu	g	km	e	**	**	†	*	*		*	*	**	*		*						
Haymaker											†				†	*									
Philadelphia	Pa.	r	m	pr	g	km	me	*											†						
Reliance	N. J.	rob	m	pr	g	km	m				*								†						
Shaffer	N. Y.	rob	l	pur	g	km	m	**	**	*	*				**	**			*		†	*			

SUBSECTION 3.—RUBUS OCCIDENTALIS.

Conrath	**Mich.**	**rob**	**l**	**b**	**vg**	**dm**	**è**		*		†	*				*								
Cumberland	**Pa.**	**rob**	**vl**	**b**	**vgb**	**dm**	**e**		*	*	*	*				*	*				†	*			
Doolittle (*Doolittle's Black Cap*)	N. Y.	r	m	b	vg	km	e	*	†		†			*	*										
Earhart	Ill.	r	m	b	g	k	el	*																	
Eureka (*Mohler*)	Ohio	r	ml	b	g	km	me		†		*					**	*								
Gregg	Ind.	rob	l	b	g	m	m	**	**	*	**	*				**	**		**		**	*			*
Hilborn	Ont.	rob	l	b	gvg	dm	e	*	†	†	†														
Hoosier	Ind.		l	b	g	dkm	e									†									
Kansas	Kans.	r	ml	b	vg	km	m	†	**	*	**				**	**	**		**		**				
Lotta	Kans.	r	ml	b	vg	km	m	*	*							*									
McCormick (*Mammoth Cluster*)	Ind.?	r	m	b	g	km	m	*		†	*								*						
Mills	N. Y.	r	m	b	vg	km	m		*																
Nemaha	Nebr.	rob	ml	b	g	m	e		*		*					**	†		*						
Ohio	Ohio?	r	m	b	g	km	e	*	*	†	*					**			*		*				
Older	Iowa	r	m	b	g	km	me	*	*							**									
Palmer	Ohio	r	ml	b	g	km	e	*	*	*	*					**			*		†				
Souhegan	**N. H.**	**r**	**ms**	**b**	**vg**	**km**	**m**	*	*	*						*			*		†				
Tyler	**N. Y.**	**r**	**m**	**b**	**vg**	**km**	**m**	*	*	*							*		*						
Winona	Ohio	r	l	b	vg	m	e				†														

SUBSECTION 4.—RUBUS STRIGOSUS.

Blair	Que.	r	m	r	vg	dk	m	*																	
Brandywine (*Wilmington*)	Del.	rc	m	r	vg	dk	e		*	*	†					*	†		*						
Cuthbert	N. Y.	rc	ml	r	vg	m	m	**		**	**	**		*		**	**		**		**	**	**	*	**
Golden (*Golden Queen*)	N. J.	rc	ml	y	vg	dk	m	**	*		*	*							*		†				
Hansell	N. J.	r	m	r	g	dm	e	*	*	†	†												**		
Kenyon	Iowa	r	l	r	g	km	m			†	†														
King (*Early King*)		r	m	cr	g	dm	e		†							**					†				
Loudon	Wis.	rc	ml	r	g	dm	m	*	*	†	*	*				**	†		*		*				*
Marlboro	N. Y.	r	l	r	g	m	m	*	*	*						*	*		**		*				
Miller	Del.	r	l	r	vg	dm	e	*	*	*	*					*					†	**			
Ruby																†									
Thwack	**N. Y.**	**r**	**l**	**pr**	**g**	**m**	**m**												†						
Turner	**Ill.**	**rc**	**m**	**r**	**vg**	**dm**	**m**	*	*	*	*					**			*						

Section 14.—STRAWBERRIES (*Fragaria*).

[KEY.—*Origin:* Amer., America; Can., Canada; Ont., Ontario, etc. *Form:* c, conical; l, long; ob, oblate; obl, oblong; r, round. *Size:* l, large; m, medium; s, small; v, very. *Color:* c, crimson; d, dark; l, light; r, red; s, scarlet. *Quality:* b, best; g, good; v, very. *Use:* d, dessert; k, kitchen; m, market. *Season:* e, early; l, late; m, medium; v, very. *Sex:* b, bisexual; p, pistillate.]

Name.	Description.								Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	Sex.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Aroma	Kans.	c	l	dr	vg	km	l	b		*						*	*	*								
Bederwood	Ill.	rc	m	ls	g	dm	m	b	*	*	*	*		*		**	**	*		**						
Belt (*William Belt*)	Ohio	obc	l	dc	vg	dm	m	b	*	*	*					*							*			
Bismarck	Ark.	rc	vl	rc	vg	......	m	b			*															
Brandywine	Pa.	obc	vl	c	vg	dm	ml	b		*	*	*		**		†	*			*		*		*	*	**
Brunette	Ind.	rc	l	dr	vgb	d	m	b		†																
Bubach (*Bubach's No. 5*)	Ill.	rob	vl	s	vg	m	e	p	**	**	**	*		*		**	*				*	*		*		
Buster	Can.?		l	lr	g	m	ml	p		*	*															
Captain Jack	Mo.	r	ml	r	g	dm	m	b										*		*						
Cardinal	Ohio	rc	ml	lc	vg	dm				†							†									
Carrie	Va.	obl	l	c	vg	m	m	p	*	*																
Chesapeake	Md.?				vg	m	ml										†									
Climax	Md.		m	dr	g	dm	e			†						†										
Cloud	La.	obc	ml	lc	vg	dm	e	p				*		*	*											
Clyde	Kans.	oblc	l	c	vg	m	me	b	*	*	*		*			†	**									
Commonwealth	Mass.		l	dr	vg	......	l	b		†																
Crawford	Ohio	rc	l	lc	vg	dm	m	b	†	*												†		*		
Crescent (*Crescent Seedling*)	Conn.	rc	m	ls	vg	m	e	p	**	*	*	*		*	*	**	**	*		**	**					
Cumberland (*Cumberland Triumph*)	Pa.	rob	vl	ls	g	m	m	b		*		*		*		*				*						
Dollar	N. J.?	rc	l	lc	vg	d	m	b														*	**	**	*	
Dornan (*Uncle Jim*)	Mich.?	r	vl	lsc	vg	m	m	b	†	†							†									
Downing (*Charles Downing*)	Ky.	rc	ml	ds	vg	dm	m	b	*	*		*		*		*	*	**		*	*	*				
Dunlap (*Senator Dunlap*)	Ill.	rc	m	dr	g	dkm	m	b	†	**						**	**	*			**	*	*			
Enhance	Ohio	c	l	lc	vg	dm	m	b		*	*	*		*			*				*					
Enormous	Ill.	obc	vl	dc	vg	dm	ml	p			*															
Eureka	Ohio	r	ml	lr	g	dm	ml	p		*		*		*						†						
Excelsior	Ark.	c	m	r	g	d	ve	b		*		*	*	*	*	†	†						*		*	
Fendall	Md.	rc	vl	lr	g	......	m	p			†															
Gandy	N. J.	c	l	lc	vg	dm	l	b	*	**	**	*	*	*	**	**	*	*		**	**	*				
Glen Mary	Pa.	rc	vl	c	gvg	dm	m	b	*	*	*	*		*			*	*		*						
Goodluck																	†	†								
Greenville	Ohio	robc	l	lc	gvg	dm	e	p	*		*	*		*		*	*			†						
Haverland	N. J.	oblc	l	s	gvg	dm	m	p	**	**	**		*			**	**	*		**	*	†				
Heflin	Va.						e				†		†													
Hoffman	S. C.	c	ml	dc	vg	dm	m	b				*	*	*	*											
Hood River	Oreg.																	*				**	*			

Hummer	Mich.?	e	m	de	gvg												†									
Jessie	Wis.	re	vl	ls	g	dm	m	b	*	*						*	*	*		*	*	*	**	*	*	
Johnson (*Johnson Early*)			ml	r	vg		e		†																	
Jucunda (*Knox's 700*)		obe	lvl	ls	g			b														*	*			
Klondike	La.	obl	l	r	gvg	dm	me	b				*		*	*	†	†									
Linda																									†	
Longworth (*Longworth's Prolific*)	Ohio	re	l	le	vg	km		b																	*	
Lovett	Ky.	oble	ml	de	vg	dm	me	b		*	*					†	*			†	*					
Luther (*August Luther*)		obl	ms	dr	vg	dm	ve	b								†		*								
Magoon	Oreg.																					**	**		*	
Manchester	N. J.	obe	m	s	vg	dm	ml	p													*					
Marshall	Mass.	re	vl	dr	vg	dm	m	b		*	*															
Michel (*Michel's Early*)	Ark.	obe	m	r	vg	dm	me	b	*	*	*	*		*	*	*					*	*	*			
Michigan (*Pride of Michigan*)										†							†					†				
Monarch (*Monarch of the West*)	Ill.	robe	l	lr	g	dm	m	b							*											
Nettie			vl	lr	vg		vl			†																
Neunan (*Neunan's Prolific*)	S. C.	e	m	ls	g	m	m	p				**		**	*											
Oregon (*Ironclad*)	Oreg.						vl	b														*	†			
Parker Earle	Tex.	oble	ml	lr	gvg	dm	m	b	†	*					*	*	**	†		*	*	**		**		
Parson (*Parson's Beauty*)			ml	dr	g		ml	b		†							†	†								
President (*President Wilder*)	Mass.	re	lvl	les	vg					†																
Ridgway	Ind.	re	l	lr	vg	dm	e	b		*																
Ruby	Eng.	oblr		ls	vg					*																
Sample	Mass.	re	l	lr	vg	dm	l	p	†	*						*	†					†				
Sandoval	Ill.	re	ml	de	g	m	e	b		*		*		*												
Saunders	Ont.	e	l	e	vg	dm	e	b	*	*	*	*		*			*			*		†				
Seaford	Del.	r	l	e	g	m	l	p			*															
Sensation	Cal.?																								†	
Sharpless	Pa.	re	vl	lr	gvg	dm	m	b	**	*	*	*		*		*	*			*	*	*	**	**	**	*
Splendid	Ill.	re	l	de		m	m	b	†	*		*		*			**					†				
Stevens (*Stevens' Late Champion*)			l		g	m	vl			†							†									
Tennessee (*Tennessee Prolific*)	Tenn.		vl	ds	g	m	m	b		†	*															
Texas	Tex.			dr	vg	m	ve	b		†					*		†	†								
Thompson (*Lady Thompson*)	N. C.	robl	l	e	g	dm	e	b			*	**	*	**	**					†		†				
Van Deman	Ark.	obe	ml	s	gvg	d	m	b		*																
Vick (*James Vick*)	Mo.	r	m	s	g	dm	m	b										*								
Virginia	Va.?	re	ml	lr	g	m	ve										†	†								
Warfield	Ill.	e	m	dr	gvg	m	e	p	*	**	*					**	**	*		*	**	*				
Williams	Can.	re	ml	de	vg	dm	e	b	†	*																
Wilson (*Wilson's Albany*)	N. Y.	e	m	de	gvg	m	me	b	*	*	*	*	*	*		*	*	*		*	*	**	**			
Woolverton	Ont.	e	ml	de	gvg	dm	m	b	*	*	*	*		*		*	*			*		†				

Section 15.—NUTS.

SUBSECTION 1.—ALMONDS (*Amygdalus communis*).

[KEY.—*Origin:* Cal., California; Eur., Europe; Tex., Texas. *Form:* b, broad; l, long; m, medium. *Flavor:* s, sweet. *Quality:* g, good; v, very. *Shell:* s, soft; t, thin; v, very.]

Name.	Description.					Recommendations for the several districts.																	
	Origin.	Form.	Flavor.	Quality.	Shell.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
California (*California White*)	Cal			vg	t																†		
Chiliense																				†			
Commercial (*Harriott's Seedling*)	Cal	l	s	vg	s																*		
Drake (*Drake's Seedling*)	Cal	b		vg	t																**		*
Eureka																					**		
Golden State	Cal	ml		g	s																*		
I. X. L.	Cal	bl		vg	s														†		*	*	**
Jordan (*California Jordan*)																					†		
Languedoc	Eur	b		vg	t															*	**	**	
Lassen																					*		
Nonpareil (*Extra*)					vt														*		**	**	*
Prolific																						**	
St. Joseph																				†			
Texas (*Texas Prolific*)	Tex																					*	

SUBSECTION 2.—CHESTNUTS (*Castanea*).

[KEY.—*Origin:* Cal., California; Del., Delaware; Fr., France; Jap., Japan; N. J., New Jersey, etc. *Size:* l, large; m, medium; s, small; v, very. *Quality:* b, best; g, good; v, very.]

Name.	Description.				Recommendations for the several districts.																	
	Species.	Origin.	Size.	Quality.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Alpha	C. crenata	N. J.	ml	g			*															
Anderson	C. sativa	N. J.	m	g			†															
Bartram	C. sativa	Pa.	m	g			†															
Beta	C. crenata	N. J.	m	g			†															
Biddle	C. crenata	N. J.	l	g			*															
Black	C. crenata	N. J.	ml	g			†															
Coe	C. crenata	Cal.	l	vg			†															
Combale (*Marron Combale*)	C. sativa	Fr.	l	g														*		*	*	
Comfort	C. sativa?	Pa.	ml	gvg			†															
Cooper	C. sativa?	N. J.	ml	vg			†					†										
Corson	C. sativa	Pa.	ml	vg			†															
Dager	C. sativa	Del.	m	gvg			†															
Darlington	C. sativa	Del.	ml	gvg			†															
Felton	C. crenata	Del.	ml	vg			*															
Hale	C. crenata	Cal.	ml	vg			†															
Hannum								†	*													
Hathaway	C. dentata	Mich.	s	vgb		†																
Kent	C. crenata	N. J.	ml	g			*															
Kerr	C. crenata	N. J.	l	vg			*	†														
Killen	C. crenata	N. J.	vl	vg			†															
McFarland	C. crenata	Cal.	vl	vg			†					†										
Martin	C. crenata	N. J.	l	g			†	†														
Miller	C. sativa?	Pa.?	m	g			†															
Moncur	C. sativa	Del.	m	vg			†															
Numbo	C. sativa	Pa.	ml	gvg		*	†	†	*									*				
Paragon	C. sativa	Pa.	ml	gvg		**	**	*	*			*						*	*			
Parry	C. crenata	Jap.	vl	g			*															
Prolific	C. crenata	Jap.	m	g			†															
Reliance	C. crenata	N. J.	ml	g		*	*											*				
Ridgeley	C. sativa	Del.	ml	vg			*	†	*			**										
Rochester												†										
Scott	C. sativa	N. J.	m	g			†	†	*													
Success	C. crenata	N. J.	l	vg			†															
Superb	C. crenata	N. J.	l	vg			†															
Styer	C. sativa	Pa.	m	g			†															

Section 15.—Nuts—Continued.

SUBSECTION 3.—FILBERTS AND HAZELNUTS (*Corylus*).

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[KEY.—*Origin:* Cal., California; Eur., Europe; Fr., France, etc. *Form:* l, long; o, oval; ob, oblong. *Size:* l, large; m, medium; v, very. *Quality:* b, best; g, good; v, very.]

Name.	Description.				Recommendations for the several districts.																	
	Origin.	Form.	Size.	Quality.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Du Chilly	Eur	ob	vl	vg														*			*	
Fertile de Contord																					*	
Nottingham																					*	
Purple Leaf	Eur	ob	l	g						*												
SUBSECTION 4. PECANS (*Hicoria pecan*).																						
Alley									†		†											
Centennial	La	ob	vl	vg						*	*											
Curtis									†		†											
Delmas											*											
Frotscher (*Frotscher Egg Shell, Olevier*)	La	ob	l	vg				†	**	*	*											
Georgia (*Georgia Giant*)											†											
Hollis (*Posts Select*, in part)											†											
Jewett	Miss	o	vl	vg							†											
Money Maker											*											
Pabst											*											
Peerless?											*											
Post (*Posts Select*, in part)											†											
Rome (*Rome, Columbia, Columbian, Pride of the Coast, Bourgeois*)										*	†											
Russell	Miss	ob	l	vg						*	*											
San Saba	Tex	o	m	vgb						*	*											
Schley								†	**		*											
Stuart (*Castanerd*)	Miss	rob	l	vg				†		*	**											
Success											*											
Teche (*Frotscher*, of some)									†		*											
Van Deman (*Paragon*)	Miss	ob	l	vg				†	**	*	*											
Young											*											

SUBSECTION 5.—PERSIAN, ENGLISH, OR EUROPEAN WALNUTS (*Juglans regia*).

Chaberte																					†	
Ford (*Ford Soft Shell*)	Cal	lov	vl	vg																	**	**
Franquette	Fr	lov	vl	vgb														**	†	**	**	*
Mayette	Fr	lov	l	vg														**	†	**	**	*
Mission (*Los Angeles*)	Cal	rov	ml	g																		**
Parisienne	Fr	rob	l	vg														*		*	*	*
Placentia (*Placentia Perfection*)																						**
Proeparturiens	Fr	ov	m	vg														*	†	*	*	*
Santa Rosa																					†	
Von Rey																					*	

Division II.—SUBTROPICAL AND TROPICAL FRUITS.

This division includes such species only as, under cultivation or otherwise, have so far varied that the departures from the original types are recognized under varietal names.

The climate of the portion of Florida lying south of 27° north latitude is so far modified by its semi-insular position, together with the softening influence of the almost tepid waters of the adjacent Gulf Stream, as practically to adapt it to the successful cultivation of many strictly tropical fruits. Such, therefore, as are recommended for cultivation in this region are indicated by the letter *s* in connection with the starring of District No. 6, of which this territory forms a part. A few of the more hardy subtropical fruits, though not succeeding in all portions of District No. 6, are successful in favored localities in adjacent portions of districts 5 and 7.

Section 1.—CITRUS FRUITS.

[KEY.—*Origin:* Braz., Brazil; Fla., Florida; For., Foreign; Jap., Japan; Port., Portugal, etc. *Form:* o, oblate; ob, oblong; ov, oval; r, round. *Size:* l, large; m, medium; s, small; v, very. *Color:* d, dark; l, light; o, orange; r, red; y, yellow. *Quality:* b, best; g, good; p, poor; v, very. *Use:* d, dessert; k, kitchen; m, market. *Season:* e, early; l, late; m, medium; v, very.]

SUBSECTION 1.—CITRONS (*Citrus medica*).

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Lemon	For.	ov	vl	oy	pg	k							*s												
Lyman	For.	ov	m	oy	pg	k							*s												
Orange	For.	r	s	oy	g	k							*s												

SUBSECTION 2.—KUMQUATS: *Syn.* KINKANS (*Citrus japonica*).

Name.	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Marumi	Jap.	r	s	oy		dkm							*												
Nagami	Jap.	ob	s	oy		dkm							**												

SUBSECTION 3.—LEMONS (*Citrus limonum*).

Belair	For	ov	ml	ly	b								*s												
Eureka	Cal	ov	ml	ly	p								*s										**	*	**
Genoa	Italy	rov	ml	ly	g																				*
Lisbon	Port	ov	ml	ly	g																				**
Sicily	Italy	ov	ml	ly	vgb								*s										**		*
Villafranca	For	ov	ml	ly	vgb								**s											*	**

SUBSECTION 4.—LIMES (*Citrus limetta*).

Boston													†s												
Imperial	For	ov	l	y	g																				**
Mexican	For	ov	m	ly	g								*s											*	*
Persian	For	ov	m	ly	vg								*s												
Peruvian																									*
Rangpur	India	o	sm	or	vgb	dkm							*s												
Tahiti	For	ov	l	ly	vgb																				*

SUBSECTION 5.—MANDARINS (*Citrus nobilis*).

China	For	o	m	lo	vg	d							*												
Dancy (*Dancy tangerine*)	Fla	o	ml	or	vg	dm							*												*
Oneco													*												
Satsuma	Jap	o	m	o	vg	dm							**											*	
Tangerona	Braz	o	m	lo	vg	dm							*												

SUBSECTION 6.—POMELOS: *syn.* GRAPEFRUIT (*Citrus decumana*).

Bowen													*												
Conner (*Conner's Prolific*)	Fla												†												
Duncan													**												
Hart	Fla	r	s	ly	g	dm	lm						**												
Mammoth	For	r	l	oy	vg	dm	l						*												
Marsh (*Marsh Seedless*)	Fla	r	s	ly	vg	dm							*												
Pernambuco	Braz	r	vl	ly	vg	dm	l						**												
Royal	Fla	r	ml	ly	vg	dm	em						*												
Triumph	Fla	r	ms	ly	g	dm	lm																	*	
Walters	Fla	r	ml	ly	g	dm	lm						**												
Woodworth													*												

Section 1.— Citrus fruits—Continued.

SUBSECTION 7.—SWEET ORANGES (*Citrus aurantium sinensis*).

Name.	Description.							Recommendations for the several districts.																
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Acapulco	For	r	l	o	g	dm	m																*	
Bahia (*Washington Navel*) [a]	Braz	rov	vl	o	vgb	dm	em					*										**	**	**
Bessie	Fla	r	l	o	vg	dm	l					**												
Blood												*												
Boone	Fla	r	ml	lo	g	dm	ve					*												
Centennial	Fla	r	m	o	vgb	dm	em					*												
Comer (*Comer Seedless*)												†												
Dugat					vg							*												
Ellwood																								*
Enterprise (*Enterprise Seedless*)	Fla	r	m	o	g	dm	e					*												
Foster	Fla	r	m	o	g	dm	e					*												
Hart (*Hart's Late*)	For	ov	m	o	vg	dm	vl					**												
Homosassa	Fla	r	m	o	vg	dm	m					*												
Imperial (*Imperial Blood*)	Fla	r	m	or	g	dm	e					*												
Jaffa	For	r	m	o	vgb	dm	m					*											*	*
Majorca	For	r	m	o	b	dm	lm					**												
Maltese Blood	For	ov	sm	or	b	dm	m					*												*
Mays (*Mays' Best*)	Fla	r	m	o	g	dm	m					*												
Mediterranean (*Mediterranean Sweet*)	For	ov	l	o	g	dm	l					*										*		*
Nonpareil	Fla	r	l	o	vg	dm	em					*												
Paper Rind (*Paper Rind St. Michael*)	For	ov	s	lo	g	dm	lm					*												
Parson (*Parson Brown*)	Fla	ov	m	o	g	dm	e					**											*	*
Pineapple	Fla	r	vl	oy	vg	dm	m					**												
Ruby	For	r	m	or	vg	dm	em					*												*
St. Michael	For	r	m	o	vg	dm	m					*												*
Thompson (*Thompson Improved*)	Cal	rov	vl	o	vgb	dm	em																*	*
Valencia (*Valencia Late*)	For	ov	l	lo	vg	dm	l					*										**	*	*
Vinous (*Madam Vinous*)	Fla	r	m	o	vgb	dm	m					*												

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[a] Well known on the Pacific coast under its synonym, Washington Navel.

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Section 2.—FIGS (*Ficus carica*).

[KEY.—*Origin:* For., Foreign; Sp., Spain. *Size:* l, large; m, medium; s, small; v, very. *Color:* a, amber; b, black; bl, blue; br, brown; g, green; p, purple; r, red; v, violet; w, white; y, yellow. *Quality:* b, best; g, good; p, poor; v, very. *Use:* c, curing; d, dessert; k, kitchen; m, market.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Size.	Color. Skin.	Color. Flesh.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Adriatic (*White Adriatic*)	For.	l	gy	r	g	cdk						*	*	*							*		*	**	
Ascolano																								*	
Black Ischia	For.	ml	rb	r	vgb	dkm							*												
Bourjassotte Grise	For.	m	br	r	vg							*													
Brunswick (*Madonna*)	For.	lvl	va	a	g	dkm						*	**	*										*	
Calimyrna																								†	
Celeste (*Celestial*)	For.	s	rva	a	vgb	dkm					*	*	*											*	
Early Violet	For.	vs	vbr	r	vg									*											
Endrich	For.	m	gy	vp	g																			*	
French													*												
Genoa (*Blue Genoa*)	For.	ml	bl		g	dkm							*												
Ischia (*White Ischia*)	For.	s	blg	r	g						*	*													
Lemon		ml	y		vgb	dkm						*	*	†											
Magnolia													*	†											
Marseillaise (*Marseillaise White*)	For.	ml	yw	a	g	cdk								*											
Mission (*California*)	Sp.	l	rv	r	vg	cd								**							*		**	**	
Monaco Bianco	For.	vl	blg	r	vg	d								**											
Narbus (*Golden Narbus*)												*													
Nerii (*White Nerii*)												*													
Osborn (*Osborn Prolific*)	For.	ml	br	r	vg	d								*											
Provence (*Provence Blanche*)												*													
Reine Blanche	For.	l			vg	d								*											
San Pedro Black		vl	vb	r	vg	d															*		*		
Turkey (*Brown Turkey*)	For.	ml	br	r	vgb	dkm					*	*	*	**							*		*	**	
White Smyrna													*										**	**	
Zimetza		vl	w		p	km								†											

Section 3.—JAPANESE PERSIMMONS (*Diospyros kaki*).

[Key.—*Origin:* Jap., Japan; Tex., Texas. *Form:* c, conical; o, oblate; ob, oblong; obo, obovate; p, pointed; r, round. *Size:* l, large; m, medium; s, small; v, very. *Color:* br, brown; c, carmine; d, dark; o, orange; r, red; s, salmon. *Quality:* b, best; g, good; m, medium; p, poor; v, very. *Use:* d, dessert; m, market. *Season:* e, early; l, late; m, medium; v, very.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Costata	Jap	rcp	m	cr	g	dm	l					*	**	*											
Goshio											†	*													
Hachiya	Jap	obop	vl	br	g	dm	e					*	*	*											**
Hiyakume	Jap	robo	l	or	pg	m	m					*	**	*											
Kurokuma	Jap	r	l	r	g	dm	m						*	*											
Mazelli												*													
Munson (*Munson Seedling*)	Tex													†											
Okame	Jap	ro	l	brc	g	dm	em				†	*	**	*											
Taber (*Taber 129*)	Jap	rp	m	or	g	dm	ve					*	*												
Tanenashi	Jap	rcp	l	br	vgb	dm	m				†	*	**	**											
Triumph												*	*												
Tsuru	Jap	obp	l	br	pg	m	vl					*	*	*											
Yeddoischi	Jap	ro	ml	dr	g	dm	m						**	*											
Yemon	Jap	rcp	l	cr	pg	m	m					*	*	*											
Zengi	Jap	ro	s	dr	pg	dm	ve						**	*											

Section 4.—GUAVAS (*Psidium*).

[Key.—*Origin:* Mex., Mexico; S. A., South America. *Form:* r, round. *Size:* m, medium; s, small. *Color:* g, green; y, yellow. *Quality:* g, good; p, poor. *Use:* d, dessert; k, kitchen; m, market. *Season:* a, autumn; s, summer.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Cattley (*Strawberry*)	S. A.	r	m	g	pg	dkm	as																	**	
Chinese (*Mexican*)	Mex.	r	sm	y	pg	km	as																	*	

Section 5.—OLIVES (*Olea europea*).

[KEY.—*Origin:* Cal., California; Fr., France; Sp., Spain. *Form:* o, oblique; ob, obovate; ov, oval; r, round. *Size:* l, large; m, medium; v, very. *Color:* b, black; d, dark; p, purple.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Ascolano																									*
Macrocarpa	Italy	ovob	vl	p																			*		
Manzanillo	Sp.	rov	l	pb																	†		**	**	**
Mission	Cal.	ov	ml	pb																	*		**	**	**
Nevadillo (*Nevadillo Blanco*)	Sp.	ovo	m	pb																				*	
Queen																					†		*		
Rubra	Fr.?	ovo	m	b																			*	*	
Santa Catarina			vl																				*	*	
Sevillano	Sp.	obo	vl	p																				**	
Uvaria	Fr.	ov	m	dp																			*		

Section 6. PINEAPPLES (*Ananas sativus*).

[KEY. *Origin:* For., Foreign. *Form:* c, conical; ob, oblong; r, round. *Size:* l, large; m, medium; v, very. *Color:* d, dark; r, red; y, yellow. *Quality:* b, best; g, good; v, very. *Use:* d, dessert; k, kitchen. *Season:* s, summer.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Abachi (*Abakka*)	For.	ob	ml	dy	vg	dk	s						*s												
Cayenne (*Smooth Cayenne*)	For.	c	vl	y	vgb	dk	s						*s												
Golden													*s												
Natal													*s												
Porto Rico	For.	r	vl	y	g	dk	s						*s												
Queen													*s												
Spanish (*Red Spanish*)	For.	r	ml	ry	g	dk	s						*s												

Section 7.—POMEGRANATES (*Punica granatum*).

[Key.—*Origin:* Amer., American. *Form:* ov, oval; r, round. *Size:* l, large; m, medium; s, small. *Color:* r, red; v, violet; y, yellow. *Quality:* b, best; g, good; vg, very good. *Use:* d, dessert. *Season:* e, early; l, late; m, medium.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Acid	Amer.	ov	vl	ry	g	d	a					*		**											
Dwarf	Amer.	r	s	r	vg	d	a							**											
Everbearing														†											
Jackson														†											
Rhoda													**												
Spanish Ruby												*													
Sweet (*Large Sweet*)	Amer.	r	vl	r	b	d	a					*		**											
Violet	Amer.	r	vl	v	b	d	a							**											

Section 8.—BANANAS (*Musa sapientum*).

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Baracoa (*Red Baracoa*)													*s												
Dwarf													*s												
Hart (*Hart Choice*)													*s												
Horse													*s												
Martinique													*s												

Section 9.—AVOCADOS (*Persea gratissima*).

[KEY.—*Origin:* Cal., California. *Form:* c, conical; obl, oblong; ov, oval; r, round. *Size:* l, large. *Color:* g, green; pu, purple; y, yellow. *Quality:* g, good; v, very.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Baldwin		ov	l	pu	vg								*s												
Chappelow	Cal	obl		pu									*s												
Family		c	l	yg	gvg								*s												
Pollock													*s												
Trapp		r	l	gy	vg								*s												

Section 10.—MANGOS (*Mangifera indica*).

[KEY.—*Form:* obl, oblong; r, round. *Size:* l, large. *Color:* g, green; r, red; y, yellow. *Quality:* g, good; v, very.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Gordon (*General Gordon*)		obl	l	gy	gvg								*s												
Mulgoba		robl	l	yr	vg								*s												

Section 11.—LOQUATS (*Eriobotrya japonica*).

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Advance																									**
Early Red																									*
Premier																									**
Victor																									**
Eulalia																									**

Division III.—NATIVE FRUITS.

PAPAW (*Asimina triloba*).

[KEY—*Origin:* Ind., Indiana. *Form:* obl, oblong. *Size:* l, large; v, very. *Color:* d, dark; y, yellow. *Quality:* g, good; v, very. *Use:* d, dessert. *Season:* m, medium.]

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Uncle Tom	Ind.	obl	vl	dy	vg	d	m				*				*										

PERSIMMON (*Diospyrus virginiana*).

Name.	Description.							Recommendations for the several districts.																	
	Origin.	Form.	Size.	Color.	Quality.	Use.	Season.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Early Golden															*										
Miller															*										
Josephine (*American Honey*)														*	*										

CODE OF NOMENCLATURE OF THE AMERICAN POMOLOGICAL SOCIETY.

The nomenclature used in this bulletin is in accordance with the rules of the American Pomological Society, adopted at Boston, Mass., on September 10, 1903, the complete text of which follows:

PRIORITY.

RULE 1. No two varieties of the same kind of fruit shall bear the same name. The name first published for a variety shall be the accepted and recognized name, except in cases where it has been applied in violation of this code.

A. The term "kind" as herein used shall be understood to apply to those general classes of fruits which are grouped together in common usage without regard to their exact botanical relationship, as apple, cherry, grape, peach, plum, raspberry, etc.

B. The paramount right of the originator, discoverer, or introducer of a new variety to name it, within the limitations of this code, is recognized and emphasized.

C. Where a variety name through long usage has become thoroughly established in American pomological literature for two or more varieties, it should not be displaced nor radically modified for either sort, except in cases where a well-known synonym can be advanced to the position of leading name. The several varieties bearing identical names should be distinguished by adding the name of the author who first described each sort, or by adding some other suitable distinguishing term which will insure their identity in catalogues or discussions.

D. Existing American names of varieties which conflict with earlier published foreign names of the same or other varieties, but which have become thoroughly established through long usage, shall not be displaced.

FORM OF NAMES.

RULE 2. The name of a variety of fruit shall consist of a single word.

A. No variety shall be named unless distinctly superior to existing varieties in some important characteristic, nor until it has been determined to perpetuate it by bud propagation.

B. In selecting names for varieties the following points should be emphasized: Distinctiveness, simplicity, ease of pronunciation and spelling, indication of origin or parentage.

C. The spelling and pronunciation of a varietal name derived from a personal or geographical name should be governed by the rules which control the spelling and pronunciation of the name from which it was derived.

D. A variety imported from a foreign country should retain its foreign name, subject only to such modification as is necessary to conform it to this code or to render it intelligible in English.

E. The name of a person should not be applied to a variety during his life without his express consent. The name of a deceased horticulturist should not be so applied except through formal action by some competent horticultural body, preferably that with which he was most closely connected.

F. The use of such general terms as seedling, hybrid, pippin, pearmain, beurre, rare-ripe, damson, etc., is not admissible.

G. The use of a possessive noun as a name is not admissible.

H. The use of a number, either singly or attached to a word, should be considered only as a temporary expedient while the variety is undergoing preliminary test.

I. In applying the various provisions of this rule to an existing varietal name which has through long usage become firmly embedded in American pomological literature, no change shall be made which will involve loss of identity.

Rule 3. In the full and formal citation of a variety name, the name of the author who first published it shall be given.

PUBLICATION.

Rule 4. Publication consists (1) in the distribution of a printed description of the variety named, giving the distinguishing characters of fruit, tree, etc., or (2) in the publication of a new name for a variety which is properly described elsewhere; such publications to be made in any book, bulletin, report, trade catalogue, or periodical, providing the issue bears the date of its publication and is generally distributed among nurserymen, fruit growers, and horticulturists; or (3) in certain cases the general recognition of a name for a propagated variety in a community for a number of years shall constitute publication of that name.

A. In determining the name of a variety to which two or more names have been given in the same publication, that which stands first shall have precedence.

REVISION.

Rule 5. No properly published variety name shall be changed for any reason except conflict with this code, nor shall another variety be substituted for that originally described thereunder.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 152.

B. T. GALLOWAY, *Chief of Bureau.*

THE LOOSE SMUTS OF BARLEY AND WHEAT.

BY

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AND

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., April 1, 1909.

Sir: I have the honor to transmit herewith a technical paper entitled "The Loose Smuts of Barley and Wheat," containing the results of recent researches by the Office of Grain Investigations into the life histories of loose smuts and the determination of methods for their prevention. These smuts have been on the increase in recent years, as satisfactory means of combating them have been unknown. The accompanying paper, prepared by E. M. Freeman, formerly Pathologist in the Office of Grain Investigations, at present a collaborator of the same Office, and Edward C. Johnson, Pathologist in the Office of Grain Investigations, not only gives much new information on the life histories of these important grain smuts, but also demonstrates a practical method for their prevention. I therefore recommend that it be published as Bulletin No. 152 of the special series of this Bureau.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE LOOSE SMUTS OF BARLEY AND WHEAT.

INTRODUCTION.

The loose smuts of barley and wheat have often been considered diseases of minor importance. Although this estimate may have been justifiable ten or fifteen years ago, it certainly is not warranted at the present time. In Wisconsin and Minnesota losses from loose smut of barley of 5 to 10 per cent are not at all uncommon, while greater losses sometimes occur. Loose smut of wheat often prevails to the extent of 3 or 4 per cent in Minnesota, and considerably higher percentages have been observed in that State and in other States. Losses exceeding half of the crop have been reported in a few cases, although these are comparatively rare. Undoubtedly the greatest loss at present is occasioned by the wide distribution of these smuts. They are practically coextensive with their host plants, and though they occur usually in small quantities the damage in the aggregate is large. They often are entirely unnoticed on account of their earliness and the absence of any conspicuous sign of them at harvest time.

The loose smuts of barley and wheat are to be considered enemies to cereal culture not only on the basis of the present damage which they cause, but also on account of the possibilities of their power of increase under favorable conditions. The barley smut in particular has demonstrated its power in Minnesota and Wisconsin, where the farmers are now wide awake to the danger. The seed of wheat and barley is infected one year, but does not produce a smutted crop until the next season, while the methods necessary for combating the disease are not simple or easily applicable. Such facts emphasize the dangerous nature of these fungous pests and make the determination of any successful method of prevention especially desirable.

DESCRIPTION OF LOOSE SMUT OF BARLEY.

There are two smuts of barley common in this country. The loose smut (*Ustilago nuda* (Jens.) Kell. & Sw.) is easily distinguished from the covered smut by its earlier appearance, by its olive-green spore mass as compared with a black spore mass in the latter, and by the early shedding of the spores, which are blown off by the wind almost as soon as the smutted head comes out of the leaf sheath. In covered smut the spore mass is compact and often persists as smut balls in the harvested grain. (See Pl. I, *d*, *e*, and *f*.)

The smutted plants head earlier as a rule than those not infected. The heading in both infected and normal plants is prolonged throughout a period of from four to fourteen days, depending on external conditions. However, the period of maximum smut development in a field always occurs at the maximum flowering time of the barley. Scattering heads on both infected and healthy plants appear until the time of harvest. Usually the smutted heads are elevated rapidly above those of the healthy plants, thus giving opportunities for a wide distribution of spores by air currents. The light weight of the smutted heads also assists them in maintaining an upright position in a heavy wind. In general, when a plant is infected every head is smutted. Occasionally, however, plants are found with some smutted and some sound heads. (See Pl. VI.)

In a smutted head usually every spikelet and every kernel is smutted. To this again there are not infrequent exceptions. When spikelets in an infected head escape the smut they ordinarily occur at the top. (See Pl. III, *b*.) In the field such heads are commonly found late in the season, i. e., shortly before harvest. Sometimes they occur in artificially infected plants when infection has taken place previous to the full flowering period.

In a smutted head as a rule each spikelet is entirely transformed into a smut mass. (See Pl. II.) The ends of the awns, however, frequently escape. These often remain as weak threadlike bodies on the end of the smut masses. The rhachis is never destroyed, and persists as a naked stalk after the spores have been blown off. In a smutted plant the smut occasionally extends to the top of the leaves, and large bract-like bodies, likewise smutted, are sometimes formed at the bases of the heads. These are probably the basal glumes or entire spikelets stimulated to abnormal development by the fungus. (See Pl. III, *c*.)

The smut masses when the head first appears are covered by a delicate grayish membrane. This soon bursts and sets free the powdery spores, which in a few days are blown off by the wind. In some seasons many of the latest formed smutted heads remain hard and black and fail to release their spores. The head, therefore, does not become powdery, but retains its mature form, and the spores are apparently never distributed. (See Pl. III, *d*.) In a normal smut head the smut mass is olive-green in color. The spores are approximately spherical and measure 5 to 7 by 5 to 6.5 μ in diameter. Seen under the microscope they are lighter colored on one side than on the other.

That there is a variation in the susceptibility to infection in different barleys seems clear from the fact that in variety tests on one-tenth-acre contiguous plats about equally exposed the different varieties show varying amounts of smut. The order of susceptibility in eight selected barley varieties, from the worst smutted to those showing no smut in 1906, was maintained in 1907. Whether this is due to an innate protoplasmic resistance during the stage of floral infection or whether it is due to differences in the time of maximum flowering period or to differences in the degree of opening of the glumes in the several varieties is not yet clear. Practically all barley varieties, both two-rowed and six-rowed, which have come under the writers' observation contain, however, some loose smut.

DESCRIPTION OF LOOSE SMUT OF WHEAT.

The loose smut of wheat (*Ustilago tritici* (Pers.) Jens.) in almost all of its characters resembles the loose smut of barley. There is a more striking difference between it and stinking smut, or bunt, of wheat than there is between the loose and covered smuts of barley. The bunt of wheat transforms only the kernels into smut balls, which do not break until the wheat is thrashed and often remain intact in the thrashed grain. The loose smut of wheat on the other hand discharges its spores even earlier than does the barley loose smut. (See Pl. I, *a*, *b*, and *c*.) The smut masses of the former are usually broken before the head gets out of the sheath, a feature not common in the latter. Loose smut of wheat is similar, however, to the loose smut of barley in all of its essential features, as just described. (See Pls. IV and V.)

The following slight differences may be noted: The smut appears at the flowering time of wheat, and thus usually in spring wheats a little later than in barley. Nothing has yet been observed in wheat similar to the bract-like or leaf-like bodies at the base of the smutted spike of barley. (See Pl. III, *c*.) The smut mass in wheat is darker than that in barley and approaches coal-black. The membrane covering it is even more delicate and breaks usually before the head is exposed to the air. The spores are spherical, 5.5 to 7.5 by 5 to 6 μ in diameter, and under the microscope are lighter colored on one side than on the other. The variation in susceptibility among wheat varieties is perhaps more marked than among the barleys. Some of the bearded spring wheats seem to be infected more easily than the common Bluestems. The smut is found, however, in practically all classes and probably all varieties of wheats.

The following records of loose smut of wheat were obtained in 1906 at McPherson, Kans., by Mr. V. L. Cory, for the Office of Grain Investigations:

> The greatest quantities of loose smut in wheat occurred in two Japanese varieties, a Roumanian wheat and a Kansas hybrid (Turkey Red × Zimmerman). The last-named variety gave 15 per cent. The appearance of this amount of smut is not readily explained. One Japanese variety (G. I. No. 1184–1, Japanese No. 1) contained 9 per cent of smut, and Onigara, another Japanese variety (G. I. No. 1695), 6 per cent. The Roumanian wheat contained about 8 per cent. The last three wheats are all early, and it is possible that on account of their earliness they are more easily subject to the wind-blown spores of loose smut than the later varieties. This does not explain the susceptibility of the hybrid mentioned above, as this was not an early variety. In regard to earliness of ripening, the Japanese wheats mentioned matured about June 22 or 23. The earliest wheat at the station was a Zimmerman which ripened June 16. It is an interesting fact that still another Japanese wheat (Japanese No. 4), which ripened at the time of the Zimmerman, was free from smut.

LIFE HISTORY STUDIES OF LOOSE SMUTS.

HISTORICAL REVIEW OF STUDIES.

In 1895[a] and 1896[b] Frank Maddox, of Launceston, Tasmania, produced what appears as the first evidence of "floral" or intra-seminal infection in the loose smuts of wheat and barley. In experiments undertaken to devise methods of prevention in the case of the loose smut of wheat he demonstrated that the ovaries of the wheat in the flowering stage could be "artificially smutted" by the application of the spores of loose smut. The grains developed from these ovaries were apparently normal, but when planted the following year almost invariably produced smutted plants. Mr. Maddox states:

> The loose smut germs on the grain or mixed with the soil are harmless and will not produce the disease. Artificially smutted is putting the smut germs on the ovary about the time the pollen is ripe, which will always reproduce the disease the following year. Pots sown in 1894, with smut added gave sound plants free from the disease, and the same pots sown in 1895 would reproduce the disease when artificially smutted, and grew sound plants in one pot. * * * The smut gets on the ovary at flowering time, the grain matures without any sign of being diseased. * * * Believe the spore is embedded beneath the epidermis or skin and is beyond reach of destruction by pickling.

The histological details of the infection were not worked out.

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[a] Maddox, F. "Experiments at Eastfield." Department of Agriculture, Tasmania, 1895.

[b] Maddox, F. "Notes and Results on Agricultural Experiments Carried on Under the Auspices of the Council of Agriculture of Tasmania at Eastfield, Newnham." Launceston, Tasmania, 1897.

Hori,[a] in discussing the question whether spores carried into the flowers may cause infection, says:

> Mr. S. Wakagawa, of our former branch station at Matsuto, carried out an experiment on this point early in 1897. He introduced the matured spores of *U. tritici* into the flowers of wheat in the same field by means of a forceps. The infected seeds were sown in the ordinary time of the autumn of the same year. In the following year the ears as soon as they appeared were found to be all smutted. Similar experiments made by Mr. K. Yamada gave the same result. Soon afterwards I obtained similar results in flower infection with *U. tritici* and *U. nuda*. Hence I concluded that the spores of those smuts which mature at the flowering time of the host, and may be scattered easily by the wind, will be retained in the inner side of the seed and give rise to the smut disease during the next flowering time of the host plant.

In 1903 Freeman [b] described an intraseminal infection of the darnel grass. The fungus which is very commonly found in this plant seldom, if ever, produces spores. It lives in the growing point of the darnel in a manner quite similar to that of the cereal smuts. Instead of forming spores in the ovary, as most smuts do, it lies in wait for the young embryo of the darnel and infects the growing point, thus passing from one generation of darnel to the next, always living in the stem-growing points and neglecting altogether, as far as is at present known, to produce spores. The histological details of this intraseminal infection were shown.

Brefeld,[c] in 1903, and Hecke,[d] in 1904, working independently and apparently without any knowledge of Maddox's work in Tasmania or Hori's investigations in Japan, again demonstrated the floral infection of the loose smuts of wheat and barley. The histological data of the growing-point infection were added to make the evidence of floral infection complete.

The life history of the loose smuts of wheat and barley may be briefly described as follows: The smut spores in the field are distributed by the wind at the flowering time of the grain plant. They are blown into the spikelets, find their way between the glumes, and come in contact with the young ovary, or stigma. Here they germinate; the germ tube penetrates the ovary wall and the fungus finds its way into the growing point of the embryo. The mycelium then continues to develop until the grain is ripe without giving any external evidence of its presence. It lies dormant inside of the seed until the grain germinates, when it continues to develop with the seedling, keeping pace with the growing point until the head is formed. It then invades all of the young spikelets and destroys them, replacing them with the smut spores.

---

[a] Bulletin, Imperial Central Agricultural Experiment Station, Japan, vol. 1, No. 2. 1907. [English.]

[b] Philosophical Transactions, Royal Society of London, series B, vol. 196, pp. 1–27. 1903.

[c] Nachrichten aus dem Klub der Landwirte zu Berlin, No. 466. 1903.

[d] Zeitschrift für das Landwirtschaftliche Versuchswesen in Oesterreich. 1904.

The life histories of the loose smuts of barley and wheat thus differ widely from those of the covered smut of barley and the stinking smut, or bunt, of wheat, where the spores are not distributed to any extent at flowering time, but get on the seed either in thrashing, in the bin, or in handling in sacks or in machinery. The spores of the latter smuts are sown together with the grain and germinate at the same time. The fungus then invades the young grain plant as it emerges from the seed, grows along with it until maturity, and forms the smut balls in place of sound grains.

EXPERIMENTS IN LIFE HISTORIES OF LOOSE SMUTS.

In order to test the validity of previous investigations, experiments in inoculations were undertaken at St. Anthony Park, Minn., in 1906 and 1907. The seeds from the inoculated plants in 1906 were planted in 1907, and the 1907 inoculations were tested in 1908.

The inoculations were made in the fields in 1906 and in special plats in 1907. Various methods as described later were employed. In testing the effect of inoculation at different stages of the flower, the following letters were used to designate the condition of the majority of flowers in the spike:

a—Before the stamens are mature.
b—At maturity of stamens.
c—Ovary just commencing to enlarge after fertilization.
d—Ovary one-third mature size.
e—Ovary two-thirds mature size.

The use of plus and minus signs serves to indicate intermediate conditions.

After inoculation some heads were covered with paraffin bags or with tissue paper, while others were left uncovered. The seeds obtained were treated before sowing with a solution of 2½ parts of formalin in 1,000 parts of water for two hours in order to insure the prevention of any infection from clinging spores of either loose or covered smut.

Fresh spores from mature smutted heads were always used as inoculating material. The spikelets were prepared for inoculation in some cases by cutting off the glumes near the base of the awns, thus leaving a slight opening between the tips of the glumes. This usually resulted in the loss of a considerable number of seeds where the flowers were in early stages of development. Other heads were left with their awns intact. The smut was applied on some heads by rubbing or brushing the outside; on others it was placed directly on the stigma and ovary by opening the glumes (as is done in artificial cross-pollination) and applying the smut with a brush or forceps. In a few cases the heads were moistened by a fine spray of water from an atomizer. A six-rowed barley (Minnesota No. 105) and a bearded spring wheat (Minnesota No. 188) were used as host plants. Both varieties produced in the field tests an average maximum of approximately 3 to 4 per cent of loose smut.

Three loose smuts were used: *Ustilago tritici* (Pers.) Jens. on wheat, *Ustilago nuda* (Jens.) Kell. & Sw. on barley, and *Ustilago lorentziana* Thüm. on wild barley (*Hordeum jubatum*). Cross-inoculations, i. e., from barley to wheat and wild barley, from wheat to barley, and from wild barley to barley, all produced negative results. The three smuts are therefore considered distinct species, incapable of transfer to the other hosts. The covered smut of barley was likewise found unable to produce infection in the flower of barley.

TABLE I.—*Results of inoculations of barley with loose smut of barley, St. Anthony Park, Minn.*

Method of inoculation.	Stage of flower inoculated.	Plants produced from inoculated seed.	Smutted plants.	
		Number.	*Number.*	*Per cent.*
INOCULATIONS MADE IN 1906; PLANTS MATURED IN 1907.				
Spores rubbed on the heads; heads not covered	a	29	14	49
	c	47	23	49
	d-e	55	0	0
	e+	48	0	0
Spores rubbed on the heads; heads covered	a-b	21	4	19
	c+	22	6	*28
	e+	118	0	†0
Spores placed on ovary; covered	a-b	14	9	64
INOCULATIONS MADE IN 1907; PLANTS MATURED IN 1908.				
Spores on ovary; heads covered	a-b	1	1	100
	b	2	2	100
	c	12	12	100
	c-d	9	8	89
	d	18	9	50
	e and e+	7	0	0
Glumes cut; spores brushed on heads; heads covered	b	22	1	5
	c	40	2	5
	c-d	18	0	0
	d	14	1	7
	d-e	30	1	3
Glumes not cut; spores brushed on heads; heads covered	c	65	1	1.5
Glumes not cut, spores brushed on heads; heads not covered.	a	4	0	0
	a-b	6	0	0
	b	16	0	0
	c-d	5	0	0
Glumes cut; spores brushed on heads; heads not covered	a	29	0	0
	b	26	0	0
	b-c	70	1	1.4

* Heads sprayed with water when inoculated.
† Part (37 plants) sprayed with water when inoculated.

TABLE II.—*Summary of Table I, showing the effect of the stage of anthesis on infection with loose smut.*

Stage of flower at inoculation.	Plants produced from inoculated seeds.	Smutted plants.		Partially smutted plants.	Healthy heads in partially smutted plants.
	Number.	*Number.*	*Per cent.*	*Number.*	*Per cent.*
INOCULATIONS MADE IN 1907; PLANTS MATURED IN 1908.					
a and a-b	64	27	42	22	35
c and c+	69	29	42	0	....
d-e	55	0	0	....	....
e+	166	0	0	....	....
INOCULATIONS MADE IN 1907; PLANTS MATURED IN 1908.					
a to a-b	40	1	2.5	....	....
b to b-c	136	4	3.0	1	10
c to c-d	149	23	15.0	4	30
d to d-e	62	11	17.0	....	....
e+	7	0	0	....	....

TABLE III.—*Results of inoculations of wheat with loose smut of wheat, St. Anthony Park, Minn.*

Method of inoculation.	Stage of flower inoculated.	Plants produced from inoculated seed.	Smutted plants.	
		Number.	*Number.*	*Per cent.*
INOCULATIONS MADE IN 1906; PLANTS MATURED IN 1907.				
Spores placed on ovary; heads covered	c?	31	8	26
Spores rubbed on heads; heads covered	c?	97	10	10
INOCULATIONS MADE IN 1907; PLANTS MATURED IN 1908.				
Spores placed on ovary; heads covered	b–c	22	7	32

In 1906 the inoculations recorded in Tables I and II, except that on August 11, were made on July 10 and 11 and the seeds planted May 11, 1907; in 1907 they were made on July 10 and 23 and the seeds planted April 23, 1908.

The 1906 inoculations recorded in Table III were made on July 6 and the seeds planted on May 13, 1907; the 1907 inoculations (Table III) were made on July 23 and 25 and the seeds planted on April 16, 1908.

The results as shown in these tables establish clearly the floral or intraseminal infection of the loose smuts of barley and wheat in this country. Inoculation in the flower produced in some heads 100 per cent of infection.

On account of the variation in the stage of flowering found in almost any head of wheat or barley, the stage designated in the table is to be interpreted as the average in that head. A common condition illustrating this variability is the following: In many heads of barley examined on July 11, 1907, stage *d* prevailed at the center of the head and stage *e* at the bottom. At the tip the flowers were for the most part slightly in advance of the base, i. e., *e–d*. The optimum time for infection is the full flowering period, viz, stage *c*. Success is common in the earlier stages, even when the stamens are green (*a*). Infection seldom, if ever, takes place in stage *e*, i. e., when the ovary is about two-thirds its natural size. The partial successes in stages *d–e* are undoubtedly due to the *d* spikelets. It may be concluded that inoculation succeeds best just after fertilization of the egg cells, when the embryo has commenced to grow, as shown in the enlargement of the ovary. This agrees with Freeman's results with darnel, where infection took place as soon as the embryo had developed the "anlage" of a stem-growing plant.

At stage *e* and beyond, either the epidermis of the ovary wall or the newly formed aleurone layer is perhaps impenetrable to the germ tubes. The stigma, moreover, has dried and probably can not transmit the germ tube. The conditions previous to stage *c* present interesting data especially in the 1906 inoculations (Tables I and II). Here a striking difference is seen between the effects of inoculation on stage *c* and the earlier stages. (See Table II.) In the former every seed inoculated produced completely smutted plants, i. e., every head was smutted. In the latter 22 out of 27 plants were only partially smutted, and the average number of sound heads was 35 per cent of the total number. It is seen that this result was not duplicated in the 1907 inoculations, where *c* stages exhibited a fairly large number of partially smutted plants (4 out of 16), with 30 per cent of sound heads. Whether this escape of heads in a smutted plant is due to the initial condition of the flowers at the time of inoculation, to the accidental escape of lateral branches in the subsequent growth, or to weather conditions inimical to the best development of the fungus can not be stated until the histological details of the infection and subsequent development are fully understood.

In accordance with what would be expected, the most efficient method of inoculation is that of placing the smut directly on the stigma and ovary, although the rubbing method is also efficient, producing 49 per cent in some cases. The rubbing tests were more successful in 1906 than in 1907, as a result, perhaps, of different weather conditions at the time of inoculation. The season of 1907 was abnormally dry. This may have prevented the spores from being washed into the flower, or the moisture may have been insufficient for spore germination. Covering the heads after inoculation does not seem to be essential.

In spite of the remarkably close pollination in barley the glumes may often be found open one-sixteenth of an inch (and in some cases even more) at the time of maturity of the stamens. They are, of course, forced apart a little later to allow the stamens to be extruded. It is undoubtedly during these open periods that the smut spores gain entrance to the flower, perhaps most frequently at the earlier one. That the opening is as wide in all flowers as that stated above is extremely improbable. Varietal differences based on the opening habits are to be expected, though up to the present none have been observed. In addition, the state of the weather during flowering time in a field must exert a great influence on distribution. The results of the following test are probably explainable only on the basis of unfavorable weather conditions. Eighty-two seeds were obtained in 1907 from wheat heads in which the glumes had been cut as previously described. These were then left exposed to natural infection. Less than 2 per cent of loose smut resulted, while 2 to 5 per cent was found among uncut control plants in the same plats.

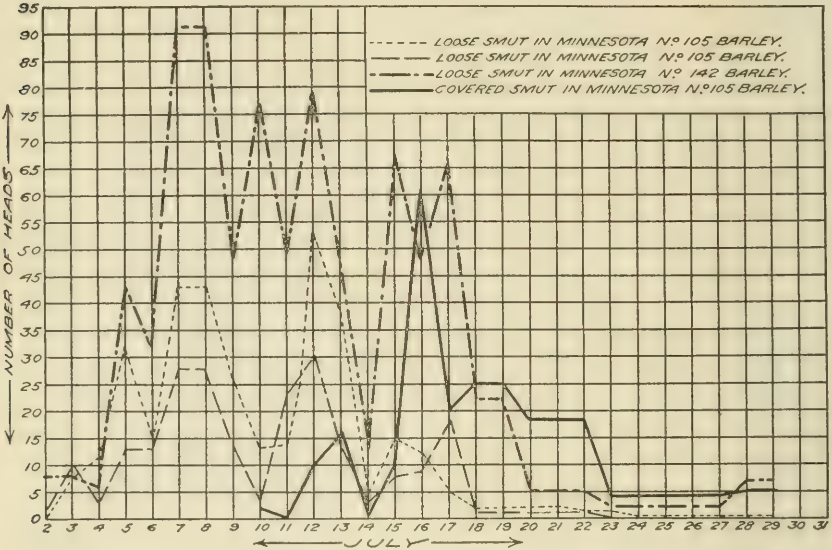

FIG. 1.—Diagram showing the daily record of barley smut at St. Anthony Park, Minn., in 1907.

The flowering period in a pure variety is, of course, fairly uniform. Stages *c* to *d* were quite general in the fields at St. Anthony Park in the barley varieties known as Minnesota Nos. 105 and 142 on July 10 and 11, 1907. Figure 1 shows the number of smutted heads picked from several one-fortieth-acre plats of barley which were rogued carefully each day. There were two plats of Minnesota No. 105 and one plat of Minnesota No. 142. One plat of Minnesota No. 105 contained covered smut, as shown in the diagram, while the other, which had been treated with formalin, had none. Minnesota No. 142 barley did not have any covered smut. The approximate median date of the maximum period of loose smut in 1907 was July 10 in Minnesota No. 105 and July 12 in Minnesota No. 142. The corresponding date for the covered smut was July 18, approximately one week later.

It will be seen that the full flowering period in 1907, viz, July 10 and 11, fell exactly on the median date of maximum smut. The later appearance of covered smut is explained in its spore habit of clinging to the grain, as do the spores of the stinking smut of wheat. The effective formalin treatment previously mentioned is strong evidence that this is the case.

The mere fact of close proximity of a head of barley or wheat to a smutted head does not necessarily insure infection. Heads of barley (Minnesota No. 105) growing close to smutted heads in 1906 were selected, and 324 plants from this seed matured in 1907 with an average of 2.2 per cent of smutted plants—less than the field average for this variety in the same year.

The phenomena of partially smutted heads introduce interesting possibilities. In such heads on wheat, for instance, various conditions may be found. In some spikelets observed in 1907 only the glumes escaped the smut; in some, the ovary alone was attacked, the ovary wall remaining apparently uninjured; in others, no smut appeared, but the ovary was aborted, and in still others apparently sound grains were produced. In partially smutted heads the upper spikelets of the head most commonly escape. Occasionally, however, the middle spikelets are sound while the spikelets above and below are smutted. No cases have been observed where the basal spikelets escape the smut. In regard to partially smutted heads the following questions arise: Do the sound grains entirely escape infection as the head develops or do they contain the fungus in a dormant stage after an ineffectual attempt to form spores has been made? The possibility of the latter condition is actually paralleled in the case of the fungus of the darnel, where the parasite regularly gets into the seeds and infects the young embryos, but does not form spores. To test this possibility sound seeds from smutted heads were collected in 1906 and 1907 and planted during the following years. To avoid external infection these were treated with formalin before planting. From such seed from the 1906 crop 98 plants of barley developed 2 per cent of smut in 1907, and 51 plants from seed from the 1907 crop developed 2 per cent of smut in 1908. In each case the amount of smut did not reach the average (3 to 4 per cent) in the field crop. It seems clear, therefore, that the sound grains in a smutted head escaped infection as far as the mycelium inside of the infected head is concerned. Similar results were obtained with loose smut of oats.

INFLUENCE OF TIME OF PLANTING ON LOOSE SMUT.

In Table IV are shown the results obtained by planting spring wheat and barley at different times to determine what effect the time of planting may have on the development of the smut. As infection took place in 1906, this is merely a test of the development of the fungus in 1907 in plants grown from the already infected seed.

TABLE IV.—*Influence of time of planting on loose smuts of barley and wheat, St. Anthony Park, Minn., 1907.*

Date of planting.	Barley, Minnesota No. 105.		Barley, Minnesota No. 142.		Wheat, *a*, Minnesota No. 188.		Wheat, *b*, Minnesota No. 188.	
	Number of heads.	Smut.	Number of heads.	Smut.	Number of heads.	Smut.	Number of heads.	Smut.
		Per cent.		*Per cent.*		*Per cent.*		*Per cent.*
Apr. 23			759	5.53			981	1.21
25			901	5.87			1,038	1.54
26	587	1.36			761	1.31		
May 6	515	.58	837	6.81	672	1.33	887	2.14
7	517	1.35	1,097	5.64	748	1.81	1,002	.89
8	788	1.65	774	5.42	831	1.56	933	1.50
9	324	2.79	743	6.46	844	.94	848	.94
10	392	1.78	551	4.53	324	2.77	751	1.33
11	281	1.78	740	4.58	517	2.70	1,025	2.14
13	325	.92	591	7.10	491	4.07	611	1.47
14	338	1.47			517	2.51		
15	110	2.72	897	6.35	581	1.37	954	3.21
16	446	1.79	695	5.46	598	3.17	740	2.43
17	359	1.39	940	4.04	745	2.68	882	1.02
20	217	3.68	665	5.56	622	2.41	558	1.07
22	249	2.81	662	5.13	545	2.56	611	1.47
24	342	1.16	843	3.91	556	3.05	553	1.44
27	191	3.15	679	3.94	441	3.40	428	2.33
29	240	1.20	712	5.05	362	1.93	351	1.70
31	262	1.14	571	3.46	335	2.08	426	1.40
June 3	200	3.5	516	2.32	252	1.98	276	.72
5	173	1.73	742	2.56	252	.79	266	1.12
7	259	.38	306	2.74	227	.44	207	.48

Barley (Minnesota No. 105) and wheat, *a* (Minnesota No. 188), were planted in a dry, sandy soil with good drainage, while barley (Minnesota No. 142) and wheat, *b* (Minnesota No. 188), were planted in a fairly heavy, low-lying, moist soil. The time of planting had no marked effect on the amount of smut. Wheat on the sandy soil contained on an average slightly more smut than that on the heavier, low-lying soil, but the difference was not great. The latest plantings showed a slight decrease. This decrease, however, is not consistent, and is certainly too small to be of practical importance, since comparatively few heads filled and the plants were badly stunted. Similar results with the same wheat and barley (Minnesota No. 188 and Minnesota No. 105, respectively) planted at intervals of about four to six days, from April 22 to May 28, were obtained in 1908.

It may be concluded, therefore, that the time of planting within the range of dates attempted does not affect to any appreciable degree the development of the loose-smut fungus in the host plant as far as spring wheats and spring barleys are concerned.

In regard to winter wheats and winter barleys the case may be different. The following experiment was performed by Mr. A. H. Leidigh, at Amarillo, Tex., in 1905 and 1906, with Tennessee Winter barley. Plantings were made from the same bulk of seed on September 21, October 12, and November 11, 1905. In 1906 the three plantings contained very different amounts of smut. The earliest, that of September 21, developed 10 to 12 per cent of smut; the October 12 planting (about the usual time of planting for that section of the country) developed 22 to 25 per cent of smut, and the November 11 planting showed less than 1 per cent. In the same season, 1906, barley from the same bulk of seed developed at Chillicothe, Tex., about 27 per cent of smut. There seems to be no doubt that the time of planting had in this case a very considerable effect on the amount of smut. Results exactly similar to these were obtained with Japanese wheat and barley by Hori,[a] who says, in part:

> It is a peculiar phenomenon that if the seeds are sown early in the season the smut proportionally increases, and vice versa. * * * In consequence the smut is comparatively rare on wheat and barley cultivated in the rice fields, because the labor of harvesting the rice, draining, plowing, and drilling delays the sowing at least one to one and a half months. That fact is no doubt due to the difference between the germinating temperature of the smut spore and that of the seeds.

It is thus seen that the results in Japan were exactly similar to those obtained by Mr. Leidigh, at Amarillo, since the Japanese wheats and barleys were winter varieties. In general, the explanation given by Hori seems probably correct, namely, that the mycelium of the loose smut requires a higher minimum temperature for germination and growth than does the wheat or barley seed. The fact that the spring wheats and barleys do not show a decrease on the earliest dates in the experiment outlined in Table IV is possibly explained by the supposition that the required temperature difference did not exist under spring grain conditions in that locality.

TREATMENTS FOR LOOSE SMUTS.

HISTORICAL REVIEW OF TREATMENTS PREVIOUSLY APPLIED.

All previous experiments with these smuts demonstrate that ordinary seed treatment is of no avail. Jensen[b] (1887–1889) devised what is known as the modified hot-water treatment, in which soaking of barley in cold water for eight hours, followed by treatment in hot water at 127° F. for five minutes, destroyed the smut. Kellerman and Swingle[a] cite the experiments made in Denmark by Jensen and add: "We therefore strongly recommend his latest form of the treatment, which is as follows: Soak the barley for four hours in cold water and then let it stand four hours longer in a wet sack. Finally dip and drain, as directed in the treatment for oat smut, for five minutes in water of a temperature of 126°–128° F., after which dry and plant as in case of oats." No recommendation of the modified hot-water treatment for the prevention of loose smut of wheat is made in this or in Jensen's reports. Kellerman[b] records numerous trials where the wheat was treated for five minutes at various temperatures after being "previously soaked." He concludes, however, that "no grounds, based on actual experiments, appear to exist for recommending the treatment of the seed with hot water or any other fungicide."

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[a] Bulletin of the Imperial Central Agricultural Experiment Station, vol. 1, No. 2, pp. 163–176. 1907. [English.]

[b] Jensen, J. L. Nye Undersogelser og Forsog over Kornsorternes Brands, 1887, p. 15; Propagation and Prevention of Smut in Oats and Barley, Journal of the Royal Agricultural Society of England, vol. 24, second series, part 2; Le Charbon des Cereales, Copenhagen, July, 1889.

Swingle,[c] basing his recommendations on experiments in Kansas planned by Kellerman and Swingle, carried out by Swingle and reported by Kellerman in 1891, in 1894 first recommended a modified hot-water treatment for loose smut in wheat as follows:

> Grain must be soaked four hours in cold water, then set away about four hours more in wet sacks, and finally treated as directed above, but only for five minutes, at 132° F. In planting use one-half more seed per acre to compensate for seed killed by the treatment. For preventing both of the smuts affecting barley the grain should be soaked as directed above and treated five minutes at 130° F., 2 degrees lower than for wheat. * * * It [loose smut of wheat] can, however, be combated by treating enough wheat to furnish seed for the following year, and this should be done when any considerable per cent of the crop is affected.[d]

In 1898 the same author made the same recommendations for preventing loose smuts of wheat and barley, but for the barley treatment added that "this treatment does not injure the seed."[e]

Maddox,[f] in 1896, found that by carefully picking out the loose smut heads in wheat for two years in succession in a 4-rod plat seed was obtained for a half acre which was almost entirely clean of smut.

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[a] Kansas Agricultural Experiment Station, Second Annual Report, 1889, pp. 283–284.

[b] Bulletin 22, Kansas Agricultural Experiment Station, 1891.

[c] Yearbook of the United States Department of Agriculture, 1894, p. 417.

[d] Yearbook of the United States Department of Agriculture, 1894, p. 412.

[e] Farmers' Bulletin 75, United States Department of Agriculture, p. 14.

[f] Maddox, F. Loc. cit.

Moore,[a] working on loose smut of barley in Wisconsin, obtained favorable results by soaking seed for twelve hours in cold water, draining one hour, and treating for ten minutes in water at 130° F.

Hori [b] was likewise able to prevent loose smuts by soaking the seed for seven hours in cold water, immersing it for a few minutes in water at 122° F. (50° C.), and finally treating it in water at 131° F. (55° C.) for five minutes.

EXPERIMENTS IN THE TREATMENT OF LOOSE SMUTS.

Jensen's treatment for loose smut was devised without knowledge of the life history of the smut. Since there seemed to be a possibility of further perfecting it, experiments were undertaken chiefly with this method.

EFFECT OF TREATMENT ON THE GERMINATION OF WHEAT AND BARLEY.

Preliminary tests were made at Washington, D. C., in February, 1907, of the effect on barley and wheat of soaking, followed by hot-water treatment. The germination tests were made in the Seed Laboratory of the Bureau of Plant Industry by W. L. Goss. Tables V and VI present the practical results of these tests, showing the duration of the soaking in cold water and the highest temperatures of hot water used, with the length of time of treatment, which resulted in a seed germination of 60 per cent or more. The results in all cases show a very marked decrease in germination when the temperatures are raised above those given in the table. Small quantities of seed were soaked in beakers for the specified time, then quickly drained, placed in wire baskets and immersed in a large tub of hot water in which the recorded temperatures were accurately maintained. The periods of treatment in hot water were 5, 10, and 15 minutes.

The percentages of the germination after treatment are also given. Each table is arranged to show (1) the highest temperature and (2) the longest duration of the hot-water treatments which gave a germination of 60 per cent or more. The control germinations of unsoaked seeds without any hot-water treatment were in all cases above 90 per cent.

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[a] Wisconsin Agricultural Experiment Station, 23d Annual Report, 1906, pp. 270-274.

[b] Loc. cit.

TABLE V.—*Effect on the germination of wheat (Spring Wheat Minnesota No. 169) of treatment with hot water preceded by a soaking in cold water, showing the highest temperature and the time limits with various treatments, Washington, D. C., February, 1907.*

ARRANGED ACCORDING TO TEMPERATURES.

Period of soaking in cold water.	Temperature of hot water (maximum).	Duration of hot-water treatment with little or no injury to germination.
Hours.	*°C.*	*Minutes.*
12–13	52.0	5, 10, or 15.
12–13	54.4	5.
6–7	52.0	5, 10, or 15.
6–7	54.0	5, 10 (70 per cent), or 15 (65 per cent).
6–7	56.0	5.
4–5	52.0	5, 10, or 15.
4–5	54.0	5, 10, or 15 (60 per cent).
4–5	56.0	5 (73 per cent).

ARRANGED ACCORDING TO DURATION OF TREATMENT.

Period of soaking in cold water.	Duration of hot-water treatment.	Temperature of hot-water (maximum).	Germination.
Hours.	*Minutes.*	*°C.*	*Per cent.*
12	15	52.0	81
12	10	52.0	86
12	5	54.4	84
6–7	15	54.0	65
6–7	10	54.0	70
6–7	5	56.0	73
4–5	15	54.0	60
4–5	10	54.0	86
4–5	5	56.0	73

TABLE VI.—*Effect on the germination of three six-rowed varieties of barley (Oderbrucker, G. I. No. 537; Mansury, G. I. No. 170; Kitzing, G. I. No. 189) of treatment with hot water preceded by a soaking in cold water.*

ARRANGED ACCORDING TO TEMPERATURES.

Period of soaking in cold water.	Temperature of hot water (maximum).	Duration of hot-water treatment with little or no injury to germination.
Hours.	*°C.*	*Minutes.*
12–13	52	5, 10, or 15 (Kitzing).
12–13	54.4	5 (Kitzing).
7–8	52	5, 10, or 15 (except 15 minutes in Kitzing).
7–8	54	5 or 10 (except 10 minutes in Kitzing).
7–8	56	5 (except in Kitzing).
4–6	52	5, 10, or 15.
4–6	54	5 or 10 (except Kitzing), and 15 in Oderbrucker.
4–6	56	5 (except Kitzing).
No soaking.	57	5, 10, or 15.
Do.	58	5 or 10.

TABLE VI.—*Effect on the germination of three six-rowed varieties of barley, etc.*—Continued.

ARRANGED ACCORDING TO DURATION OF TREATMENT.

(O, Oderbrucker; M, Mansury; K, Kitzing.)

Period of soaking in hot water.	Duration of hot-water treatment.	Temperature of hot water (maximum).	Germination.
Hours.	*Minutes.*	*°C.*	*Per cent.*
12-13	15	52	K-88.
12-13	10	52	K-97.
12-13	5	54	K-70.
7-8	15	52	O-92, M-86, K-48.
7-8	10	54	O-77, M-82, K-14.
7-8	5	56	O-85, M-71, K-15.
4-6	15	54	O-72, M-52, K-25.
4-6	15	52	O-90, M-98, K-68.
4-6	10	54	O-92, M-97, K-54.
4-6	5	56	O-84, M-71, K-24.
No soaking	15	57	O-98, M-99.
Do	10	58 *	O-96, M-96.
Do	5	58 *	O-95, M-97.

* Probably not the extreme limit; no higher temperature was tried.

All of the seed used was good fresh seed of the 1905 and 1906 crops, with the possible exception of the Kitzing barley, which, although the control gave 96 per cent of germination, looked old and badly weathered. The inability of the Kitzing barley to endure as severe treatments as the other barleys may have been due to this fact. In general, therefore, the treatments mentioned were accepted as the maximum in severity which would prove at all practicable.

Experiments were then undertaken based on the results recorded in Tables V and VI. These experiments with Jensen's modified hot-water treatment are shown in Tables VII to XII, inclusive. The treatment in each case is designated by three figures—e. g., 5–5–56—in which the first figure gives the number of hours of soaking in cold water, the second the number of minutes of soaking in hot water, and the third the temperature of the hot water in degrees centigrade. Treatment 5–5–56 is therefore a five-hour soaking in cold water, followed by a five-minute soaking in hot water at 56° C. Since small quantities of seed were used, a draining of only a few minutes was deemed necessary. The amount of seed was so small compared with the bulk of hot water that the temperature of the latter was seldom affected even slightly. The actual duration of soaking in some cases varied slightly from that given in the tables, but never to the extent of one hour's difference (except where noted). These variations, amounting mostly to fifteen and twenty minutes, are without doubt negligible. The duration of the hot-water treatments is in every case correct within a few seconds.

The temperature record (except when otherwise noted) is correct within 0.5° C. In all tests and treatments the centigrade scale has been used. In many cases the temperature was held absolutely constant throughout the treatment. As the tests were made for the most part at intervals of 2 degrees, the slight variations of less than 0.5° C. are likewise negligible, especially when the practical application of the results is considered. The laboratory germination tests (made by W. L. Goss in the Seed Laboratory of the Bureau of Plant Industry) are given in percentages. The field germination in most cases is estimated as excellent (E), good (G), fair (F), poor (P), or very poor (VP). In Table X the field germination is accurately computed and given in percentages.

Some seed was treated at Washington, D. C., during the winter or early spring months and kept thoroughly dry after treatment until it was planted at St. Anthony Park, Minn. Other seed was treated at St. Anthony Park just before planting and was not allowed to dry completely before seeding, which usually took place on the same or the following day. In 1907 the seeding was interrupted by snowstorms, and the treated seed was then kept moist and cool for several days in a tin box, which was packed in sawdust in an icehouse, so that no germination took place before seeding. The varieties used were those which had shown large amounts of smut at the Minnesota Agricultural Experiment Station in previous years. No actual counting tests of the amounts of smut had previously been made, and when such tests were made in 1907 the standards of percentages used in the Minnesota station's previous records were found to be too high, so that they could be used only in general comparisons. Particulars as to the dates of planting, the germination in the field, and the details of smut pickings have been omitted from the tables. The seeds were in all cases planted at the usual time for these grains at St. Anthony Park.

HOT-WATER TREATMENT OF BARLEY.

The results of the experiments with barley in 1907 are recorded in Table VII. The barleys used were Minnesota Nos. 142, 144, and 145. In 1906 No. 142 contained the most smut; Nos. 144 and 145 were affected about equally and had considerably less than No. 142. In 1907 field plats of No. 142, according to careful estimates, contained 4.62 per cent of smut.

TABLE VII.—*Results of experiments with Jensen's modified hot-water treatment on barley, at Washington, D. C., and at St. Anthony Park, Minn., 1907.*

Treatment.	Minnesota No. 142.*				Minnesota No. 144.*				Minnesota No. 145.*				Minnesota No. 142.†			
	Germination in laboratory.	Germination in field.	Number of heads.	Smut.	Germination in laboratory.	Germination in field.	Number of heads.	Smut.	Germination in laboratory.	Germination in field.	Number of heads.	Smut.	Germination in laboratory.	Germination in field.	Number of heads.	Smut.
				P. ct.				*P. ct.*				*P. ct.*				*P. ct.*
Control	97	E	332	6.95	94	E	512	0.78	98	E	486	7.40	97	E	1,801	3.65
0-10-58	93	E	469	5.75	91	E	360	1.94	90	E	495	6.87	.....	E	1,298	4.77
0-15-56	93	E	444	7.20	92	E	494	0	96	E	668	9.28	.....	E	1,517	3.75
5-5-56	94	F	323	2.47	86	F	259	.38	96	F	462	.43	.....	G	844	.14
5-10-54	96	F	426	.93	92	F	292	.34	92	E	274	0	.....	E	1,295	.07
5-15-52	90	E	467	0	88	E	357	0	96	E	823	0	.....	E	1,337	.07
7-5-54	92	E	412	0	72	E	295	0	93	E	507	0	.....	E	1,279	0
7-10-54	52	F	205	0	62	F	174	0	90	G	421	0	.....	G	992	0
7-15-52	87	G	303	0	78	G	280	0	94	G	366	0	.....	E	1,186	0
12-5-54	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	E	1,204	0
12-10-54	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	F	568	0
12-15-52	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	E	1,178	0
15-5-54	63	P	230	0	74	P	172	0	88	P	351	0	.....	.....	.....	.....
15-10-54	12	VP	77	0	12	VP	34	0	56	VP	274	0	.....	.....	.....	.....
15-15-52	60	P	458	0	72	P	136	0	88	F	344	0	.....	.....	.....	.....
24-5-54	.....	P	.....	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	F	861	0
24-10-52	.....	F	.....	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	G	1,262	0
24-15-52	.....	P	.....	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	G	1,091	0

* Treated at Washington, D. C., March 15, 1907.

† Treated at St. Anthony Park, Minn., about May 4, 1907, before sowing, but thoroughly dried before planting.

The control and the "no-soak" treatment gave plants which matured two to three days earlier than any of the other treatments. Soaking more than twelve hours, even when followed by mild treatments (ten to fifteen minutes at 52° C.), impaired germination decidedly.

Temperatures above 54° C., e. g., 56° C. for five minutes, did not prevent all of the smut but impaired germination both in the dried and freshly treated seeds. The indicated treatment lies therefore in a previous soaking of between four and twelve hours, a hot-water treatment of from five to fifteen minutes, and temperatures of 52° to 54° C. A treatment of more than five minutes at 54° C., after soaking from seven to twelve hours, injured germination in most cases.

The most successful treatment, both in the prevention of smut and in unimpaired germination, was a soaking of from five to seven hours in cold water followed by a fifteen-minute soak in hot water at 52° C. An even longer soak, e. g., twelve hours, did no damage to germination in freshly treated seed.

Drying after treatment was apparently not injurious to the smut-preventing power of the treatment and did not seriously affect the germination.

Extensive experiments similar to those recorded in 1907 were undertaken in 1908 to test these results. Unfortunately the barley used (Minnesota No. 195), though recorded as having considerable smut in 1907, produced almost no smut in 1908, the control giving no smut. The results were therefore useful only in connection with the data on germination, and these were in accord with those shown in Table VII. Experiments in regard to germination after the various treatments made with Boehme's white-bearded hull-less barley (G. I. No. 533) gave similar results throughout.

The success of Jensen's method lies without doubt in the soaking in cold water. Soaked seed probably allows a more uniform conduction of heat through the embryo than dry seed. There is, however, another effect which is, perhaps, of even greater importance. Soaking may stimulate to activity the contained smut mycelium. It seems possible, therefore, that Jensen's treatment on the one hand is efficient merely because of the increased conductivity brought about by soaking and on the other because it stimulates the mycelium to growth, in which condition it is more easily injured by the hot-water treatment. In order to throw light on this point, and also to devise, if possible, a method less injurious to the seed than Jensen's treatment the following experiment was undertaken in 1908: Some barley was soaked in ice water at a temperature of 3° C., and some in cold water at ordinary temperatures, viz. 20° C., for comparison. The results are recorded in Table VIII.

TABLE VIII.—*Results of experiments with Jensen's modified hot-water treatment on barley (Minnesota No. 142), St. Anthony Park, Minn., 1908.*

Treatment.	Seed soaked in ice water (3° C.).			Seed soaked in cold water (20° C.).		
	Germination in field.	Number of heads.	Smut.	Germination in field.	Number of heads.	Smut.
			Per cent.			*Per cent.*
Control	E	1,453	2.0	E	1,453	2
6-5-52	E	976	2.5	E	*1,000	0
6-10-52	E	996	2.2	E	*1,000	0
6-15-52	E	941	1.0	E	*1,000	0
6-5-54	E	1,115	.9	E	*1,000	0
6-10-54	E	844	1.3	F	†1,000	0
6-15-54				VP	†1,000	0
6-5-56	E	839	1.3	VP	†1,000	0
6-10-56	P	671	.4	0		
6-15-56	VP			0		
6-5-58	VP	521	.7	0		

* Approximate figures. † Less than 1,000.

The cold-water soaking treatments confirm those of 1907 in regard to smut prevention and germination. The ice-water soaking, however, is seen to be entirely inefficient against the smut and therefore valueless. This is probably best explained by the inability of the low-temperature soaking to stimulate the dormant fungous mycelium to any considerable growth. If this is true, the temperatures which after the cold-water soaking are sufficient to kill the growing mycelium without seriously affecting the germinating embryo have little or no effect upon the almost dormant mycelium after the ice-water soaking. A similar explanation might also be given for the inability of the hot-water treatment without any previous soaking (see Table VII) to prevent smut. In the experiments on wheat (Table X), ice-water soakings for twelve and thirteen hours were efficient in smut prevention, as were also soakings of six hours followed by temperatures of 56° C. or more, but in the latter case germination was seriously impaired by most of the treatments. These facts suggest, furthermore, that the soakings in ice water for six hours stimulate the mycelium, but to such a slight degree that it requires high and injurious temperatures (56° C.) to destroy the smut in its almost dormant stage.

HOT-WATER TREATMENT OF WHEAT.

The results of experiments with wheat are presented in Table IX (1907) and Table X (1908). A bearded, hard spring wheat (Minnesota No. 188) was used in all the experiments. This variety developed considerable smut in 1906. In 1907 counts made in the fields showed in general 3 to 4 per cent of smut, and in 1908 similar counts showed as much as 5 per cent.

TABLE IX.—*Results of experiments with Jensen's modified hot-water treatment on wheat (Minnesota No. 188), St. Anthony Park, Minn., 1907.*

Treatment.	Planted soon after treatment.			Seed dried after treatment.		
	Germination in field.	Number of heads.	Smut.	Germination in field.	Number of heads.	Smut.
			Per cent.			*Per cent.*
Control	....	2,856	1.29	....	2,856	1.29
0-10-58	E	2,060	1.35	G	1,752	2.16
0-15-58	G	1,793	1.72	F	1,596	1.25
5-5-56	E	2,357	0	E	2,309	0
5-10-54	E	2,450	0	E	1,856	0
5-15-54	E	1,841	0	E	1,716	0
7-5-56	E	2,160	0	E	1,414	0
7-10-54	E	2,306	0	E	2,102	0
7-15-54	E	1,873	0	E	1,767	0
13-5-54	E	2,454	0	E	1,998	*0
13-10-52	E	2,416	0	E	2,383	*0
13-15-52	E	2,444	0	E	2,050	*0
24-5-54	G	1,392	0	F	1,164	.08
24-10-52	G	1,661	0	F	1,422	.14
24-15-52	F	1,517	0	F	551	0

* Soaked in cold water for twelve hours.

TABLE X.—*Results of experiments with Jensen's modified hot-water treatment on wheat (Minnesota No. 188) at Washington, D. C., and St. Anthony Park, Minn., 1908.*

Treatment.	Seed soaked in ice water (0.6°–1.5° C.).*				Seed soaked in cold water (15° C.–17° C.).*				Seed soaked in ice water (3° C.).†			Seed soaked in cold water (20° C.).†		
	Germination in laboratory.	Germination in field.	Number of plants.	Smut.	Germination in laboratory.	Germination in field.	Number of plants.	Smut.	Germination in field.	Number of heads.	Smut.	Germination in field.	Number of heads.	Smut.
	P. ct.	*P. ct.*		*P. ct.*	*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*		*P. ct.*	*P. ct.*		*P. ct.*
Control	92.5	68	135	2.96	92.5	68	135	2.96	E	1,257	4.6	E	1,257	4.6
5-5-52	93.0	80	159	3.12	94.5	81	162	.61	E	1,771	2.9	E	1,567	.1
5-10-52	92.0	82	163	2.45	95.0	85	169	0	E	1,383	3.1	E	1,200+	0
5-15-52	94.5	79	158	3.16	95.0	79	158	0	E	1,572	3.2	E	1,200+	0
5-5-54	91.0	83	166	3.01	93.0	82	163	0	E	1,587	1.2	E	1,200+	0
5-10-54	85.5	73	145	2.75	92.5	75	150	0	E	1,368	.8	E	1,200+	0
5-15-54	80.5	71	141	.70	80.0	66	131	0	E	1,401	.3	G	1,200+	0
6-5-56	92.5	74	147	2.72	81.5	66	132	0	E	1,298	.3	G	1,000−	0
6-10-56**	71.5	70	139	.71	30.0	40	80	0	G	1,405	.4	VP	1,000−	0
6-15-56	36.5	50	99	0	3.0	7	13	0	F	794	0	VP		
6-5-58	61.0	50	100	0	2.5				P	1,040	1.0	0		
6-10-58	8.5	13	25	0	0									
6-15-58	1.0	0			0									
12-5-52††	91.0	81	162	1.85	92.5	82	163	0						
12-10-52	96.5	80	160	1.25	89.5	79	158	0						
12-15-52	87.5	78	155	0	88.5	74	147	0						
12-5-54	89.0	80	160	0	89.5	69	138	0						
12-10-54	82.5	74	148	0	80.5	58	116	0						
12-15-54	77.5	66	131	0	72.0	49	98	0						
13-5-56	73.5	51	101	0	65.0	22	44	0						
13-10-56	15.0	32	63	0	0									
13-15-56	1.0	7	13	0	0									
13-5-58	4.5				0									
13-10-58	0				0									
13-15-58	0				0									

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* Treated at Washington, D. C., January 29, 1908; planted at St. Anthony Park, Minn., April 15 and 16, 1908.

† Treated at St. Anthony Park April 17, 1908; planted at St. Anthony Park April 18, 1908.

** Average, 55.4° C.

†† 51°–51.4° C.

The results of the treatments shown in Tables IX and X are seen to be similar to those with barley. Wheat, however, shows ability to endure longer soaking and slightly higher temperatures. Treatments of ten minutes at 54° C., even after a soaking of twelve hours, gave good results both in germination and smut prevention.

The most desirable treatment is apparently the following: Soaking for five to seven hours in cold water followed by immersion in hot water at 54° C. for ten minutes.

The ice-water treatments likewise gave results similar to those of barley—i. e., they were inefficient against the smut except at high temperatures injurious to germination.

EFFECT ON GERMINATION OF DRYING TREATED SEED.

In the experiments of 1908 with both wheat and barley, data on the effect of the drying of the treated seed on germination were obtained. Part of the seed was treated January 29, and tests for germination were made in the Seed Laboratory on the following dates: January 31, February 6 and 20, and March 5 and 19. The remainder of the seed was treated February 4, 1908, and laboratory tests were made February 3, 13, and 20, and March 5 and 19. The seed was planted April 16. The tests were made from seed from both ice-water and cold-water soakings followed by the hot-water treatments. The results with both barley and wheat and from both treatments were similar. In all treatments which were not injurious to germination the tests at the different dates gave practically the same results (fig. 2, curves B and F). Where the treatment was injurious, however, the germination tests on different dates showed in general an improvement in vitality as the length of time after treatment increased, giving on the average the highest germination percentages on the last date, March 19 (curves C, D, G, and H). These relatively high percentages were sustained in the field germination tests, though all of the treated as well as all of the control seed, after having been kept dry, gave field germination tests uniformly lower than in the Seed Laboratory tests. This fact, as shown by the controls, was probably

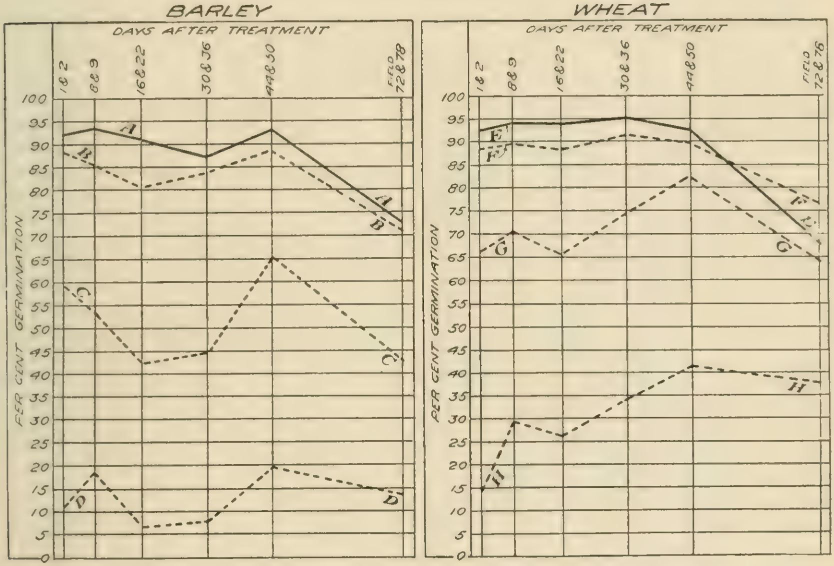

FIG. 2.—Diagram showing the effect on germination of drying the seed of barley (Minnesota No. 195) and wheat (Minnesota No. 188) after the application of Jensen's modified hot-water treatment for loose smut. The treatments were made January 29 and February 4, 1908, at Washington, D. C. The germination tests were made the number of days indicated after treatment. The first figures (1, 8, 16, etc.) give the dates after the treatment of February 4; the second figures (2, 9, 22, etc.), dates after that of January 29. The seed was planted at St. Anthony Park, Minn., April 16, 1908. *A*, barley, control (no treatment); *B*, barley, average of 19 tests, initial test between 100 and 76 per cent, inclusive; *C*, barley, average of 6 tests, initial test between 75 and 51 per cent, inclusive; *D*, barley, average of 11 tests, initial test less than 51 per cent; *E*, wheat, control (no treatment); *F*, wheat, average of 20 tests, initial test between 100 and 76 per cent, inclusive; *G*, wheat, average of 5 tests, initial test between 75 and 51 per cent, inclusive; *H*, wheat, average of 11 tests, initial test less than 51 per cent.

due to field conditions. In some cases wheat which immediately after treatment, January 31, showed no germination, on March 19 showed 30 per cent and in the field 40 per cent. The results indicate that after the drying of the seeds after treatment a delay of one to two months not only does not injure but improves the germination where seeds have been severely treated. The detailed results of these tests are shown in Tables XIII and XIV, inclusive.

EFFECT OF JENSEN'S MODIFIED HOT-WATER TREATMENT ON THE YIELD OF GRAIN.

The percentages of germination in the foregoing tables indicate that from many of the treatments a decreased yield must result unless allowance is made in planting for injury to the seed. Those treatments selected as the best for barley (5–15–52) and wheat (5–10–54) cause little or no injury to germination. Swingle's method for wheat showed that successful treatment for loose smut of wheat was accompanied by a loss of as much as 25 per cent of the seed. Results of experiments to determine the effect of the treatments on yield are shown in Table XI. Plats of one-twentieth acre at St. Anthony Park, Minn., and of one-tenth acre at McPherson, Kans., were planted in each case. These plats were close together on a uniform soil, thus giving an accurate basis for comparison. In seeding no allowance was made for injury to seed germination. In general the stand on the treated plats appeared less uniform and slightly poorer than on the control plats. The yields were tested in a manner similar to that used for the testing of varieties at these stations.

In estimating the amounts of smut in fields which were too large to permit a count of all the heads or plants the following method, proposed by Mr. H. J. C. Umberger, has been found useful and accurate and has been adopted throughout. In this method a point is selected at random in one of the drill rows, and starting from this point in the row 100 heads are counted. A hand counting register is very useful in this work. Another starting point is then selected in a different row at some distance from the first and another 100 heads are counted. This is continued over the entire plat usually until the sum of a thousand heads is reached. The exact number of counts is determined by the size of the plat and the desire for accuracy. The greater the number of counts the more accurate is the result. In some cases only 600 heads were counted, in which case some of the plats were again checked up. At other times as many as 2,000 heads were counted in each plat. This method of estimating the prevalence of smut has some advantage over the hoop or square measure methods, especially in speed, and is even more accurate than these methods, by reason of the fact that the number of heads really expresses comparatively the number of plants, which is not always the case when other methods are followed.

TABLE XI.—*Results of experiments with Jensen's modified hot-water treatment on wheat and barley, showing the effect on yield of grain.*

ST. ANTHONY PARK, MINN., 1908.

Treatment.	Barley.			
	Minnesota No. 105.		Minnesota No. 195.	
	Smut.	Yield per acre.	Smut.	Yield per acre.
	Per cent.	*Bushels.*	*Per cent.*	*Bushels.*
Control	2	37	1.4	40.0
5-15-52*	Trace.	37	0	42.2
Ice 5-15-52	0.1	33.9	.1	33.7
	Wheat: Minnesota No. 188.			
Control	3.9	24.3	6+	22.3
5-10-54	† Trace.	**20.6	Trace.	**21.6
Ice 5-10-54	4.2	20	3	††20.3

McPHERSON, KANS., 1908.

Treatment.	Spring wheat: Kubanka No. 2094.		
	Smut.	Yield per acre.	Remarks.
	Per cent.	*Bushels.*	
Control	0.25	13.46	
8-15-54	0	11.63	Temperature varied from 53.5-54° C.; 54° C. most of time.
Ice 8-15-54	Trace.	12.42	Temperature varied from 53.5-54° C.; 54° C. most of time.
	Barley: Caucasian No. 90.		
Control	1.25	35.83	
6-15-51.5	0	26.15	Temperature varied from 51°-51.5° C.; 51.5° C. most of time.
Ice 6-15-51.5	0	29.48	Temperature varied from 51°-51.5° C.; 51.5° C. most of time.

* For Minnesota No. 195, soaked 6 hours 20 minutes.
† Five heads found in whole plat.
** Temperature varied from 52.8° to 54° C.; 53.8° C. most of time.
†† Temperature varied from 54° to 53.2° C.; 53.4° C. most of time.

The uneven stand of the treated grain has already been noted. The cold-water soakings gave uniformly excellent results in the prevention of smut, leaving in no case more than a trace. This trace amounted to five heads or less in the whole plat, found by very careful search. In barley, Minnesota No. 195, not a smutted head was seen. The control in this case, however, had very little smut (1.4 per cent). The ice-water soakings were less successful, especially in wheat, where in one plat the treated grain had 4.2 per cent against

3.9 per cent in the control. These results confirm those shown in the previous table.

The yield at St. Anthony Park was slightly decreased by the treatment after cold-water soakings, while at McPherson it was quite seriously affected. In Minnesota barley it was practically equal to the control plat (exceeding it in Minnesota No. 195). In wheat there was a decrease in all cases, amounting to 15 per cent in one plat. Treatment after ice-water soakings invariably resulted in a loss in yield amounting in Minnesota No. 195 barley to 20 per cent. The ice-water treatments should, therefore, be discarded as undesirable in all respects.

Treatment after cold-water soakings, on the other hand, was successful in the prevention of smut, although a loss in yield was evident in most cases.

TEST OF THE JENSEN MODIFIED HOT-WATER TREATMENT ON A LARGE SCALE.

An attempt was made in 1907 and 1908 to test the Jensen hot-water treatment under the difficulties present at an experiment station where larger fields and more of them were planted than were found necessary in the previously described experiments. This work was conducted by Mr. H. J. C. Umberger, at McPherson, Kans., on the cooperative experiment station of the Office of Grain Investigations. There had been considerable smut at the station in 1906 in both wheat and barley, and an accurate estimate of the amount in most of the varieties in large plats was made in 1907. It was proposed to clean the entire place of smut in one year. All wheats and barleys on the station, with the exception of the hybrids, were treated in the fall of 1907. The hybrids, on account of a possible loss of seed, which could not be replaced, were left untreated.

The apparatus used in treatments was a 40-gallon galvanized-iron tub and a 2-burner gasoline stove. This and all other material necessary could easily be duplicated on an ordinary farm. The following treatments were employed: For wheat, 7–15–54, and for barley, 6–15–52. The conditions at the experiment station were, of course, even more difficult than on an ordinary farm, on account of the large number of varieties which it was necessary to handle. All treated seed was dried after treatment for at least a week previous to sowing.

The station farm comprised about 30 acres, fully one-half of which was in wheat and barley. There were 59 plats of wheat and barley of one-tenth and one-twentieth acre each, the majority being one-tenth-acre plats. An accurate smut record of 45 of the 59 plats was kept in 1907, while of the remaining 14 no record was taken, though probably smut was present. The smut varied from a trace on some plats to a maximum of 7.3 per cent on others, the average of the plats being 2.1 per cent. All computations were made by Mr. Umberger according to the method previously described. In addition to the large plats, 550 varieties and selections, comprising about 2,000 rows, were individually treated. One man's time, nine hours a day for about two weeks, was consumed in this work. It was estimated that 40 lots of seed for as many one-tenth-acre plats were treated in five hours. This rate can be considerably increased with larger tubs and more heat and where only one or two varieties are handled, as under ordinary farm conditions.

The results of these treatments became evident in 1908. Not a head of smut could be found on the whole farm among the barley and common wheats (*Triticum vulgare*). A few varieties of durum wheats, however, had an occasional smutted head, constituting an exceedingly small fraction of 1 per cent. This probably indicates that durum wheats require a slightly more severe treatment than common wheats. The untreated hybrids, which, as previously stated, were the only untreated plants on the farm, contained 2 per cent of smut in 1908. This is the only check on the amount of smut at the station for the year. Conservatively estimated, it represents the percentage of smut eliminated by the treatment. The injury to germination caused by treatment was variable. It was not more than 25 per cent in any case where the seed was properly dried and kept dry, and probably on the average was less than 15 per cent under such conditions.

As shown by other experiments noted in this bulletin, the amount of time given to the drying of treated seed was undoubtedly unfavorable to germination. The seed might better have been planted immediately or allowed to rest for one to two months. It should also be pointed out that the injury to germination did not necessarily mean a commensurate decrease in yield. It seems probable that the yield was not affected to the extent shown by the decrease in germination, since the fewer plants had greater opportunities for stooling. This attempt to clean the farm of smut in one year was without question successful and demonstrated the possibility of using this method on a fairly large scale.

Mr. A. H. Leidigh, of Hutchinson, Kans., successfully used the modified hot-water treatment on his farm in 1907–8. In a letter to the Office of Grain Investigations, he says:

> During vacation last fall I treated some Tennessee winter barley (from McPherson station) for loose smut as per specific directions from Mr. Umberger, of your office. This was for a farm field of barley; the work was done with ordinary farm equipment. I take pleasure in telling you that the modified hot-water treatment as used is a success. As the loose smut is increasing rapidly and is not to be controlled by ordinary methods, I consider our results of great importance.

ROGUING TREATMENT FOR THE PREVENTION OF LOOSE SMUTS OF WHEAT AND BARLEY.

Maddox[a] found that by carefully picking out all smutted heads in small plats seed almost free of smut was obtained in two years. Experiments were undertaken in 1907 at St. Anthony Park to test this method and to determine its practical possibilities. The results are shown in Table XII.

TABLE XII.—*Results of experiments in the prevention of loose smuts of wheat and barley by roguing the smut, St. Anthony Park, Minn., 1907 and 1908.*

BARLEY.

Plat.	Variety.	1907.		1908.
		Treatment.	Smut.	Smut.
			Per cent.	*Per cent.*
C	Minnesota No. 105	Control; no treatment	*1.69	2.0
A	do	Rogued	1.69	.2
B	do	Formalin; rogued	1.16	.5
E	Minnesota No. 142	Control; no treatment	*4.62	2.0
D	do	Formalin; rogued	4.62	1.0

WHEAT.

Plat.	Variety.	Treatment.	Smut.	Smut.
F	Minnesota No. 188	Control	3 to 4	5.0
T	do	Formalin; rogued	.2	.5
S	do	do	4.0	.1

* Percentage from rogued plats.

Five plats (one-fortieth of an acre each) were laid off for the barley work. Three of these (A, B, and C) were sown to barley, Minnesota No. 105, and two (D and E) to Minnesota No. 142. Both barleys contained considerable smut in 1906. Plats C and E were control plats and were not treated. In plats B and D the seed before planting was immersed for two hours in a formalin solution (1 pound of formalin to 45 gallons of water) in order to test the efficiency of this treatment for both loose and covered smut. In these plats, as well as in plat A (which was not treated with formalin), all of the smut was picked every day. By frequent roguing it was hoped to get the smut heads before they had a chance to distribute their spores. The details of the pickings are shown graphically in figure 1, p. 16.

The five plats of barley were grown together in a row in order to test the roguing method under fairly adverse conditions. Roguing was very thoroughly carried out, and in the three plats pickings were made daily from July 2 to harvest (July 29). The time spent in roguing averaged approximately fifty hours per plat, an amount of time hardly allowable in farm practice. The test shows, however, the possibilities of the method even under the adverse conditions brought about by the close proximity of plats C and E to the rogued plats. In plats C and E the smut was allowed to be distributed in a natural manner and undoubtedly caused infection in adjacent plats. The nearest large barley fields were 600 feet to the west of these experimental plats. The percentage of smut in 1907 was 1.69 in Minnesota No. 105 and 4.62 in Minnesota No. 142 in the rogued plats (A and D). These were accepted for the controls, since the seed used in plats C and E was from the same bulk as the seed for A and D, respectively. In plat B (Minnesota No. 105) 1.16 per cent of smut was present. The seed obtained from these plats was planted in twentieth acres in 1908. The controls (C and E) were planted in the barley variety series, while the seed from the rogued plats A, B, and D was planted among the oat varieties remote from any barley fields. The smut in each plat was computed as previously described in connection with Table XI. The results show a decided decrease in smut in every rogued plat from that recorded for 1907. The decrease would undoubtedly have been greater if the rogued plats had been completely isolated the previous year (see Table XII, plat S). The results obtained indicate clearly that the smut can be greatly reduced by roguing the smutted heads as soon as they appear. It is almost certain, however, that this method would not prove practicable in farm practice on account of the time necessary to rogue even a small plat. It could be used only in connection with a seed-plat system.

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[a] Maddox, F. Loc. cit.

Results similar to those obtained with barley were obtained with the loose smut of wheat. Minnesota No. 188, a bearded hard spring wheat, was used. Plats F and S were from the same bulk of seed. Plat T was from a different lot of seed, and no control was planted. T and S were one-tenth-acre plats both in 1907 and 1908, while control F was a large field at the station. Plat S was isolated among the barley varieties in 1907, while plat T was sown among the wheat varieties, with a plat of Minnesota No. 188 on one side and Preston wheat on the other. It was hoped that plat T would give a test of the roguing under unfavorable conditions, similar to the barley tests described above, but the amount of smut in 1907 was only 0.2 per cent as compared with 4 per cent in plat S and 3 to 4 per cent in the large fields. This small amount of smut makes the results in plat T of comparatively little value as a test for the roguing method. Plat S, however, shows conclusively the possibilities of the method when the rogued plat is isolated, since the decrease from 4 per cent in 1907 to 0.1 per cent in 1908 stands out in sharp contrast to the results in the large field controls, viz, 3 to 4 per cent in 1907 and 5 per cent in 1908.

The above experiments show that picking out the loose smut heads in both wheat and barley will decrease the amount of smut in the following crop. The best results are obtained by isolation of the plat (see Table XII, plat S), but a decrease is obtained even without isolation when the picking is carefully done. The roguing can be facilitated by pulling out the entire plant whenever a smut head appears. This will avoid the necessity of picking out several other smut heads later in the season. Planting the grain in rows 10 to 12 inches apart in order to allow walking between the rows also aids the roguing process.

The necessity for isolation is well shown in another series of experiments. From the treatment tests with Jensen's method made in 1907, Table VII, eight lots of seed of Minnesota barley No. 142 (1907 controls contained 6.9 per cent of smut), from which the smut had been entirely eradicated by the hot-water treatment, were selected. Since the treated grain had been sown in contiguous plats, the successfully treated rows during the season of 1907 were subject to inoculation by spores from the unsuccessfully treated and control plats which were usually less than a rod away. This seed from the smut-free rows when planted in 1908 gave in every case loose smut varying from 0.16 per cent to 2.4 per cent. The latter amount was equal to the untreated control of 1908, in Table XII, and shows an infection equal to that in nontreated seed. The same number of lots of wheat (Minnesota No. 188) was selected from successfully treated seed (Table IX) in 1907 under conditions similar to those described for barley. The results were in general the same. Although the seed came from rows with no smut in 1907, every lot contained smut varying from 0.1 per cent to 0.5 per cent in 1908. The increase in the smut was not as marked as in the barley, since the field control of the same wheat in 1908 had 5 per cent of smut, but in no case did the seed remain free from smut. Isolation is therefore very necessary to the maintenance of freedom from loose smut in both wheat and barley.

Just how far removed from a smutted field a plat must be in order to prevent infection entirely can not be definitely stated at this time, as no experiments have been performed to determine this point. Evidence presented in this bulletin indicates, however, that sufficient isolation of a seed plat can be obtained on an ordinary farm to avoid any considerable infection, and the maintenance of such a plat will soon reduce the smut on the farm to a mere trace and will ultimately eradicate it. Wind-borne spores travel long distances, but the possibilities of infection decrease very rapidly with the increase of the distance of the seed plat from the smutted fields. An intervening grove or strip of wood between the seed plat and the smutted field is a very valuable protection.

In connection with the above-described treatments of barley for loose smut, tests made with the covered smut showed that the latter can be easily and completely destroyed by the hot-water treatments, such as 5–15–52, or by immersion in a solution of 1 pound of formalin to 45 gallons of water for two hours. Undoubtedly other treatments, such as are efficient for the bunt of wheat and the loose smut of oats, would also be useful against this smut. The roguing method carried on in connection with loose smut (see fig. 1 and Table XII) was fairly successful against covered smut in one case (Minnesota No. 105, Table XII, plat A). In another case (Minnesota No. 142, Table XII, plat C), where no covered smut appeared in the rogued plat in 1907, 1 per cent was present in 1908. The simplicity and efficiency of the formalin treatment make the practical consideration of the roguing method for the covered smut entirely unnecessary.

TABLE XIII.—*Effect on germination of drying the seed of barley after the application of Jensen's modified hot-water treatment, Washington, D. C., and St. Anthony Park, Minn., 1908.*

Treatment.	Date of treatment.	Germination tests of Seed Laboratory.					Germination in field, planted April 16.
		January 31.	February 6.	February 20.	March 5.	March 19.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Control		92.0	93.5	91.0	87.0	93.0	73.0
Ice 5-5-52	Jan. 29	93.0	95.5	92.0	91.5	92.0	79.0
Ice 5-10-52	...do	87.5	88.0	89.0	87.0	88.0	80.0
Ice 5-15-52	...do	85.5	92.0	89.5	89.0	92.5	82.0
Ice 5-5-54	...do	90.0	90.5	87.0	85.5	91.5	73.0
Ice 5-10-54	...do	85.5	83.5	72.0	80.0	87.0	70.0
Ice 5-15-54	...do	58.5	60.5	48.0	47.5	72.0	45.0
Ice 5-5-56	...do	70.0	77.5	70.5	62.5	80.0	65.0
Ice 5-10-56	...do	23.0	43.5	16.0	15.0	37.5	34.0
Ice 5-15-56	...do	5.5	7.0	3.0	2.5	20.0	17.0
Ice 5-5-58	...do	12.0	....	11.5	....	25.0	18.0
Ice 5-10-58	...do	1.5	....	5.0	....	3.5	2.0
Ice 5-15-58	...do	1.0	....	0	....	1.5	2.5
5-5-52	...do	95.5	96.5	95.5	95.0	95.5	87.0
5-10-52	...do	94.0	94.0	93.0	90.0	91.5	76.0
5-15-52	...do	92.0	94.0	94.0	92.0	93.5	77.0
5-5-54	...do	94.0	92.5	91.0	91.5	93.5	73.0
5-10-54	...do	80.5	79.5	79.5	81.0	85.0	63.0
5-15-54	...do	48.5	41.5	35.5	42.5	65.5	39.0
5-5-56	...do	11.5	37.0	21.5	17.0	46.5	33.0
Ice 13-5-52	Feb. 4	89.0	....	91.0	90.5	95.0	75.0
Ice 13-10-52	...do	89.5	77.0	79.0	86.0	88.0	77.0
Ice 13-15-52	...do	84.5	84.5	76.5	73.5	77.5	60.0
Ice 13-5-54	...do	87.0	93.0	85.0	81.0	89.5	76.0
Ice 13-10-54	...do	76.5	73.0	58.0	53.5	79.0	56.0
Ice 13-15-54	...do	51.5	37.0	29.5	37.5	58.0	38.0
Ice 13-5-56	...do	73.5	73.5	58.5	56.0	75.0	49.0
Ice 13-10-56	...do	22.0	24.0	10.5	12.0	31.5	20.0
Ice 13-15-56	...do	2.5	4.0	1.0	1.0	3.0	2.0
Ice 13-5-58	...do	4.5	0	5.0	0	6.5	5.0
13-5-52	...do	95.5	....	82.0	....	92.0	75.0
13-10-52	...do	92.5	....	70.5	....	88.5	60.0
13-15-52	...do	84.5	63.0	31.5	....	76.0	44.0
13-5-54	...do	89.5	89.0	75.5	74.0	86.0	68.0
13-10-54	...do	56.5	32.0	10.5	20.5	40.0	24.0
13-15-54	...do	4.5	9.0	2.5	3.5	13.5	3.0
13-5-53	...do	28.5	26.0	5.5	12.5	30.0	13.0

TABLE XIV.—*Effect on germination of drying the seed of wheat after the application of Jensen's modified hot-water treatment, Washington, D. C., and St. Anthony Park, Minn., 1908.*

Treatment.	Date of treatment.	Germination tests of Seed Laboratory.					Germination in field, planted April 16.
		January 31.	February 6.	February 20.	March 5.	March 19.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Control		92.5	94.0	94.0	95.0	92.5	68
Ice 5-5-51.5	Jan. 29	91.0	93.5	94.5	95.0	93.0	80
Ice 5-10-51.5	...do.....	90.5	91.0	91.0	95.0	92.0	82
Ice 5-15-51.5	...do.....	85.5	90.5	89.5	93.0	94.5	79
Ice 5-5-53.5	...do.....	87.5	89.5	92.0	94.5	91.0	83
Ice 5-10-53.5	...do.....	75.5	91.5	83.0	91.5	85.5	73
Ice 5-15-53.5	...do.....	53.5	76.0	70.0	79.0	80.5	71
Ice 5-5-55.5	...do.....	68.5	81.0	79.5	88.0	92.5	74
Ice 5-10-55.5	...do.....	39.5	72.5	56.5	78.5	71.5	70
Ice 5-15-55.5	...do.....	20.0	34.0	34.0	37.5	36.5	50
Ice 5-5-57.5	...do.....	8.5	50.0	46.0	52.5	61.0	50
Ice 5-10-57.5	...do.....	0	3.0	15.0	3.5	8.5	13
5-5-51.5	...do.....	93.5	94.5	94.5	94.5	94.5	81
5-10-51.5	...do.....	89.5	96.0	91.5	97.0	95.0	85
5-15-51.5	...do.....	91.0	94.0	91.5	95.5	95.0	79
5-5-53.5	...do.....	87.0	92.0	92.5	92.5	93.0	82
5-10-53.5	...do.....	67.0	85.0	90.5	92.0	92.5	75
5-15-53.5	...do.....	21.5	62.0	62.5	67.0	80.0	66
5-5-55.5	...do.....	21.5	73.0	62.0	72.5	81.5	66
5-10-55.5	...do.....	0	12.5	9.5	12.5	30.0	40
Ice 13-5-51.5	Feb. 4	89.5	93.0	90.0	92.0	91.0	81
Ice 13-10-51.5	...do.....	87.5	89.0	92.5	90.0	96.5	80
Ice 13-15-51.5	...do.....	93.0	95.5	82.5	94.5	87.5	78
Ice 13-5-53.5	...do.....	89.5	91.5	91.5	90.5	89.0	80
Ice 13-10-53.5	...do.....	85.5	80.0	83.5	67.0	82.5	74
Ice 13-15-53.5	...do.....	81.5	76.0	65.5	82.5	77.5	66
Ice 13-5-56	...do.....	67.5	52.0	41.0	52.5	73.5	51
Ice 13-10-56	...do.....	21.5	12.0	6.5	4.5	15.0	32
Ice 13-15-56	...do.....	4.0	.5	0	1.5	1.0	7
13-5-51.5	...do.....	93.5	93.0	95.0	93.5	92.5	82
13-10-51.5	...do.....	93.0	86.5	89.5	94.5	89.5	79
13-15-51.5	...do.....	88.0	88.5	91.0	92.0	88.5	74
13-5-53.5	...do.....	90.5	88.0	90.0	91.5	89.5	69
13-10-53.5	...do.....	90.0	....	76.0	....	80.5	58
13-15-53.5	...do.....	74.5	58.5	47.5	60.0	72.0	49
13-5-56	...do.....	18.0	2.0	0	14.0	65.0	22

RECOMMENDATIONS.

According to the experiments previously described, two methods gave a decrease of smut. The first of these, the roguing method, although it decreases the smut does not eliminate all of it, and is, moreover, impracticable in handling large fields or even in small fields, on account of the work which it involves. It is useful, however, in nursery plats where hybrid plants and small quantities of pedigreed seed are being raised and where injurious treatments would mean a loss of seed that could not be replaced. An attempt to use it in combination with a seed-plat method would require several years at least to eliminate all of the smut. It can not, therefore, be recommended as a treatment for general practice in preventing loose smut.

The second method is Jensen's modified hot-water treatment. This has been entirely successful. It can not at present be recommended for the treatment of seed for large areas, however, but in combination with a seed-plat system it is entirely practicable and its use can be urged for general farm practice.[a] Its application requires care and intelligence, and it can best be used with small lots of seed. In general, the method to be recommended is the following: The keeping of a seed plat the seed for which has been cleaned of smut by the application of Jensen's modified hot-water treatment and the use of the grain from this plat for seed the succeeding year, when no further treatment is necessary. If the farm is very large it may require several years to get the smut entirely eliminated from the whole farm. This recommendation involves two processes, which will now be described.

SELECTION OF THE SEED PLAT.

A good, clean, well-cultivated piece of land should be selected and set aside for the raising of seed for the succeeding year. For this plat seed should first be carefully cleaned and selected by the best fanning and sifting processes. This seed should then be treated as directed later. The plat ought to be large enough to provide at least twice as much grain as will be necessary for farm seed the following year, in order to allow for loss in cleaning and selecting. This seed plat must not be placed next to fields of smutted crops of the same cereals. The plat ought also to be located so that the prevailing winds at flowering time will not carry spores to the seed plat from a neighboring field of the same grain. The isolation of this plat from smutted crops of the same cereal is absolutely necessary, not only from crops on the owner's farm but from neighboring farms as well. A strip of wood, a cornfield, a large meadow, or a barley or oat field intervening between the wheat seed plat and fields of smutted wheat will be useful, and similarly a field of corn, oats, or wheat or a large meadow or strip of wood between the barley seed plat and the smutted field will be a valuable protection. This point can not be too strongly emphasized and the cooperation of neighbors may be necessary to carry it into effect.

TREATMENT OF THE SEED FOR THE SEED PLAT.

After seed for the plat has been properly cleaned it must be treated by the Jensen method to eliminate the smut. This can be done according to the following directions: The clean seed should be soaked for from five to seven hours in water at ordinary room temperature, 17 to 22° C. (63 to 72° F.). It should be placed in small, loose sacks or wire baskets containing not more than one-half peck each and drained for a short time. It is of the greatest importance that the seed be treated in small lots in order that all of the grain may be quickly and uniformly brought to the desired temperature. Two tubs or vats of water should be provided. In one tub (No. 2) the exact temperature required should be maintained. The other tub (No. 1) is used for bringing the grain to the temperature of the treatment, so as not to lower the temperature in tub No. 2. Galvanized-iron tubs of 20 to 40 gallons capacity and kerosene or gasoline double-burner stoves are sufficient for treatment. The drained sacks or baskets of seed should be plunged into tub No. 1 for a minute, then transferred to tub No. 2, and kept agitated while immersed at temperatures and for the periods specified below, the temperatures mentioned being maintained as nearly as possible:

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[a] It may be possible to construct machines to make a general farm practice of treatment of large lots of seed possible, but none such is at present on the market.

For barley, 15 minutes at 52° C. (125.6° F.).
For wheat, 10 minutes at 54° C. (129.2° F.).

In treating barley, if the temperature should rise above 52° C. (125.6° F.) the time of immersion must be reduced to ten minutes at 53° C. (127.4° F.) or five minutes at 54° C. (129.2° F.). Above 54° C. (129.2° F.) there is no safe margin. If the temperature falls slightly below 52° C. (125.6° F.) the time of treatment should be increased in proportion. A temperature lower than 51° C. (123.8° F.) will not be effective. In treating wheat, if the temperature should rise above 54° C. (129.2° F.) or fall below 52° C. (125.6° F.), the time for immersion must be diminished or increased accordingly. Under no circumstances should a temperature of more than 55° C. (131° F.) be allowed. Temperatures below 51° C. (123.8° F.) are ineffective.[a]

Seed treated as indicated may be planted as soon as it is sufficiently dry to run freely through the drills. Allowance must then be made for the swollen seed and also for injury in treatment. The increase due to swollen seed can be estimated by measuring seed before and after treatment. The seed may be treated several months before seeding time and then dried quickly and carefully. In many cases the grain germinates as well or better when rested after treatment than if sown immediately. The seed may be dried by spreading it out in thin layers not over 2 inches in depth on a clean granary floor or on canvas and shoveling or raking it from time to time. It must not be allowed to sprout. Care must be taken to prevent the freezing of the grain when it is moist, as this will impair germination.

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[a] Two men working together can easily treat one bushel of grain an hour, or enough seed in one day to sow a seed plat from 6 to 10 acres in size.

A good thermometer should be used for all treatments.[a] The use of an instrument which is not accurate will result in injury to the germinating power of the grain on the one hand or in failure to prevent the smut on the other.

Several weeks before sowing, the seed should be tested for germination. This can be done by placing several small lots of grain of 100 seeds each between damp blotters and keeping them at a living-room temperature for several days. The percentage of sprouted kernels will show the power of germination. If this is low, a corresponding increase in the rate of seeding is necessary.

The seed plat should be maintained from year to year, at least as long as any smut is present on the farm. Seed obtained from the treated seed plat does not have to be treated the following year. All fields that are free from smut must be kept separated, as previously stated, from smutted fields of the same grain. Cooperation with neighbors may be necessary to bring this about.

SUMMARY.

The loose smuts of wheat and barley demand treatment in many sections of the United States on account of their wide distribution, evident increase, and possible virulence, and on account of the difficulty of preventing them.

The loose smuts of wheat, barley, and wild barley are distinct species and are not interchangeable as to their host plants.

The loose smuts of wheat and barley infect the plant in the flowering stage and enter the embryo inside of the ovary before the latter ripens into the seed. An infected seed develops a smutted plant the following year.

Varietal differences in susceptibility to these smuts have been observed in both wheat and barley, but no immunity of marked practical value has been discovered. There apparently is no constant relationship between susceptibility and earliness of ripening.

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[a] Thermometers may be submitted to the Bureau of Standards, Washington, D. C., for test. A charge of about 50 cents will be made for testing at the two points necessary. They should be graduated in single or half degrees—centigrade—directly upon the stem or upon a scale contained within the stem, and should preferably read from 0° to 100°. The bulbs, at least, should be made of a suitable glass, such as Jena "Normal" thermometer glass or Corning Medium thermometer glass, in order that the readings may not change with time, and the general construction of the thermometer should be good. However, thermometers with the Bureau of Standard's certificates can be purchased directly from manufacturers or large dealers, and this is generally a much more convenient way to secure them, because it avoids the risk and expense of shipping them to and from Washington.

Artificial inoculations of flowers with loose smut from the time when the stamens are still green to the time when the ovary is one-third its mature size are usually successful. The optimum period for artificial inoculation is at the time when the flower is in full bloom or when the ovary is just commencing to develop after fertilization.

The time of maximum smut in a field of wheat or barley corresponds exactly with the full flowering period of the crop.

The partial smutting of plants and of heads is common; this is possibly associated with the time of inoculation or with weather conditions. Sound grains on partially smutted heads are not infected by the mycelium growing inside the plants on which the seeds are formed.

The time of planting of spring wheats and barleys had no effect on the loose smuts at St. Anthony Park, Minn. In winter barleys at Amarillo, Tex., however, very late planting resulted in almost no smut, while planting at the ordinary time or earlier in the season resulted in a large amount of smut. The absence of smut on the late plantings is probably due to a difference in optimum temperature for the internal smut and the seed germinations.

The effects of Jensen's method on the germination of wheat and barley for different periods of previous soaking and for different temperatures and time limits are shown in Tables V and VI. In general the germination is injured, though variously, according to the severity of the treatments.

The effects of Jensen's method on the loose smut of wheat and barley for different periods of previous soaking, different temperatures, and times of treatment are shown in Tables VII and VIII. The best treatments are the following: For barley, a soaking in cold water for five hours, followed by a soaking in hot water for fifteen minutes at a temperature of 52° C.; for wheat, a soaking in cold water for five hours, followed by a soaking in hot water for ten minutes at a temperature of 54° C. These treatments if carefully carried out entirely prevent the smut and produce only slight injury to the germination of the seed.

Thorough drying of the seed after the application of Jensen's modified hot-water treatment is not injurious to the germination. When seed is injured by the treatment, the germination improves after several weeks of drying, and continues to improve for at least two months. (See Tables VIII, XIII, and XIV, and fig. 2.)

Soaking the seed in ice water previous to the hot-water treatment is not as efficient against smut as soaking in cold water at ordinary temperatures.

The application of Jensen's modified hot-water treatment will result in a decrease in yield, unless an allowance for slightly injured germination is made in sowing. With the best treatments the decrease is very small.

Picking out the loose smut of wheat and barley decreases smut even without isolation of the plat; the decrease is more marked, however, when the plat is isolated. The roguing method is nevertheless impracticable in farm practice on account of the time required and because it does not completely clean out the smut. It is useful, however, in breeding plats.

The treatment of wheat and barley seed with formalin has no effect on the loose smut. The use of formalin will, however, completely prevent covered smut of barley and bunt of wheat.

All smuts of wheat and barley, including bunt and loose smut of wheat and covered and loose smut of barley, were practically eliminated from a 30-acre experimental farm in one year by the use of Jensen's modified hot-water treatment. This method can therefore be used on a fairly large scale where accuracy and care are employed.

The following method for farm practice is recommended: Grow seed in a small isolated seed plat, using clean, heavy seed of the best quality and of pure stock. Treat this seed carefully by Jensen's modified hot-water method as recommended in this bulletin and sow the seed according to germination tests. Plant the seed from the seed plat the following year for the general farm crop. Maintain the seed plat every year.

PLATES.

DESCRIPTION OF PLATES.

[The photographs for all plates were made by Mr. H. D. Ayer, Minnesota Agricultural Experiment Station, St. Anthony Park, Minn.]

Plate I. Heads of wheat and barley, showing the common smuts. *a*, Bunt or stinking smut of wheat (Fife); head to the right with glumes removed to show smutted kernels (smut balls) in place; two whole and two broken smut balls shown below. *b*, A sound head of wheat (Minnesota No. 188), with sound grains shown below. *c*, Loose smut of wheat (Minnesota No. 188); to the right a head from which all of the spores have been blown, leaving the bare stalk. *d*, Two heads of covered smut of barley (Minnesota No. 105). *e*, A sound head of barley. *f*, Loose smut of barley; to the right a head from which the spores have been blown.

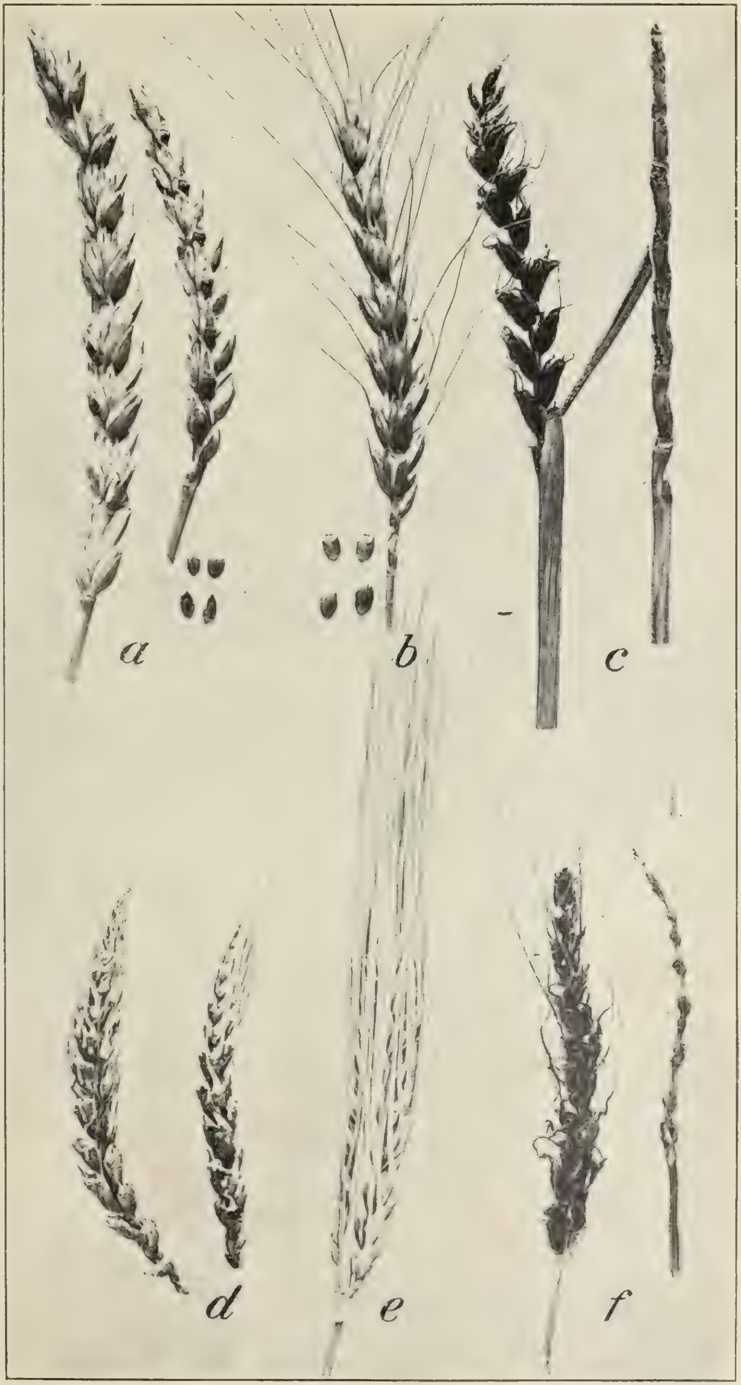
Plate II. Loose smut of barley (Minnesota No. 105), showing the various stages in the development of a smutted head. *a*, Head just appearing in the boot (sheath); *b*, half out of the boot; *c*, mature in size, but not yet distributing spores; *d*, smut mass broken and distributing spores; *e*, all of the spores blown off and the bare stalk of the head left.

Plate III. Loose smut of barley (Minnesota No. 105), showing various manifestations of smut. *a*, Sound head; *b*, partially smutted head, upper spikelets sound; *c*, completely smutted and mature head, showing powdery mass of smut; *d*, smut head formed late in the season and never developing a powdery mass of spores; *e*, a badly smutted head, showing a smutted bract at the base of head.

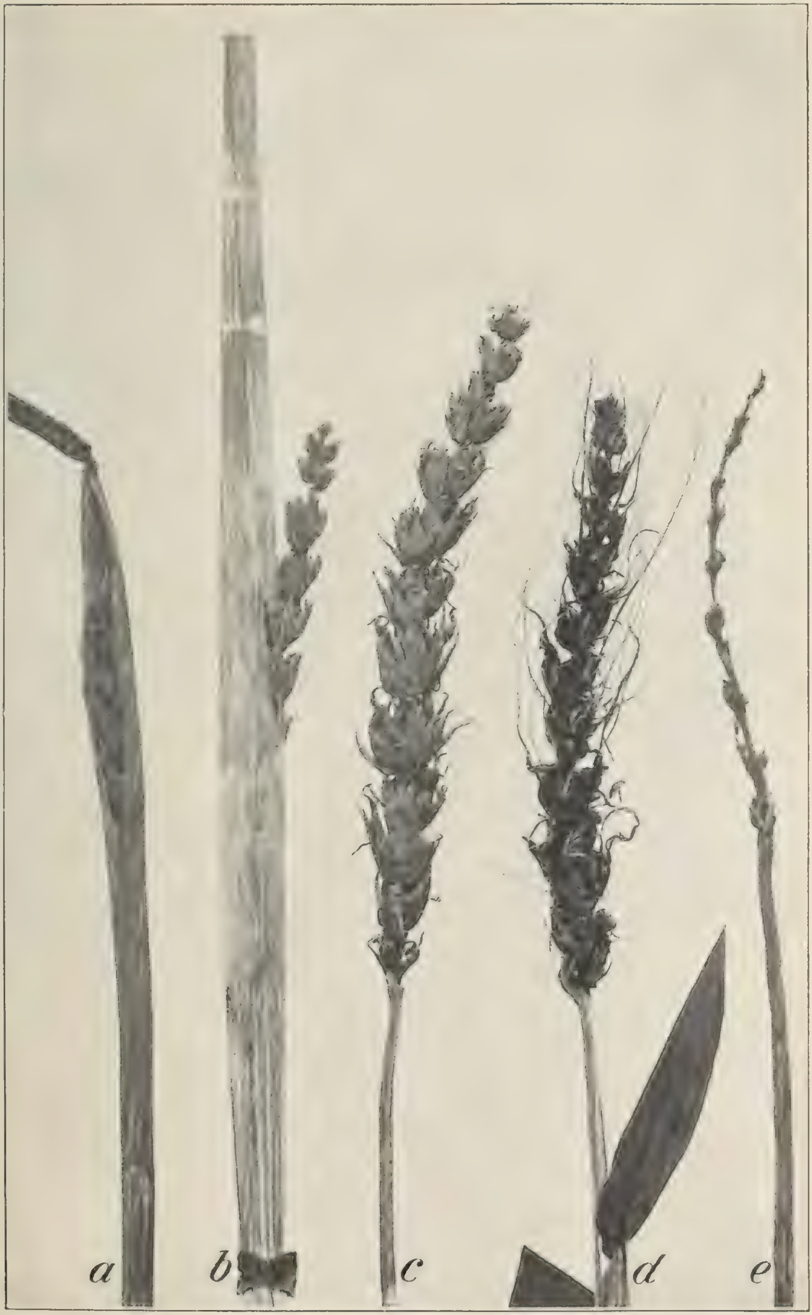
Plate IV. Loose smut of wheat, showing the various stages in the development of a smutted head as described for barley in Plate II. The smut is broken into powdery masses as soon as the head emerges from the boot. (Compare with Plate II.)

Plate V. Loose smut of wheat (Minnesota No. 188). *a*, All of the heads of one sound plant—all sound; *b*, all of the heads of one smutted plant—all smutted; *c*, a partially smutted head of wheat—upper spikelets sound.

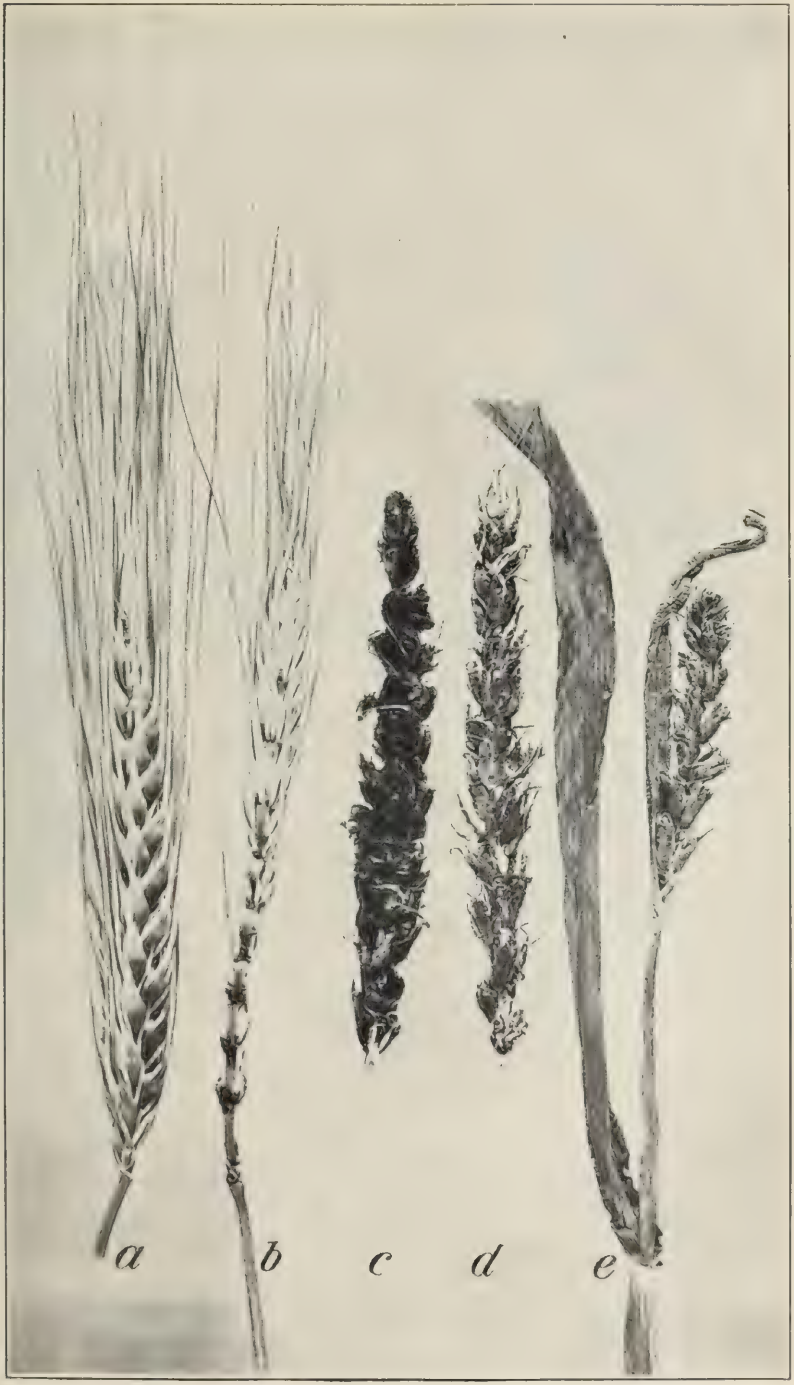
Plate VI. Loose smut of barley (Minnesota No. 105). Upper row—all of the heads of one sound plant—all sound; lower row to the left—all of the heads of one smutted plant—all smutted; lower row to the right—all of the heads of a partially smutted plant—six smutted and one sound.



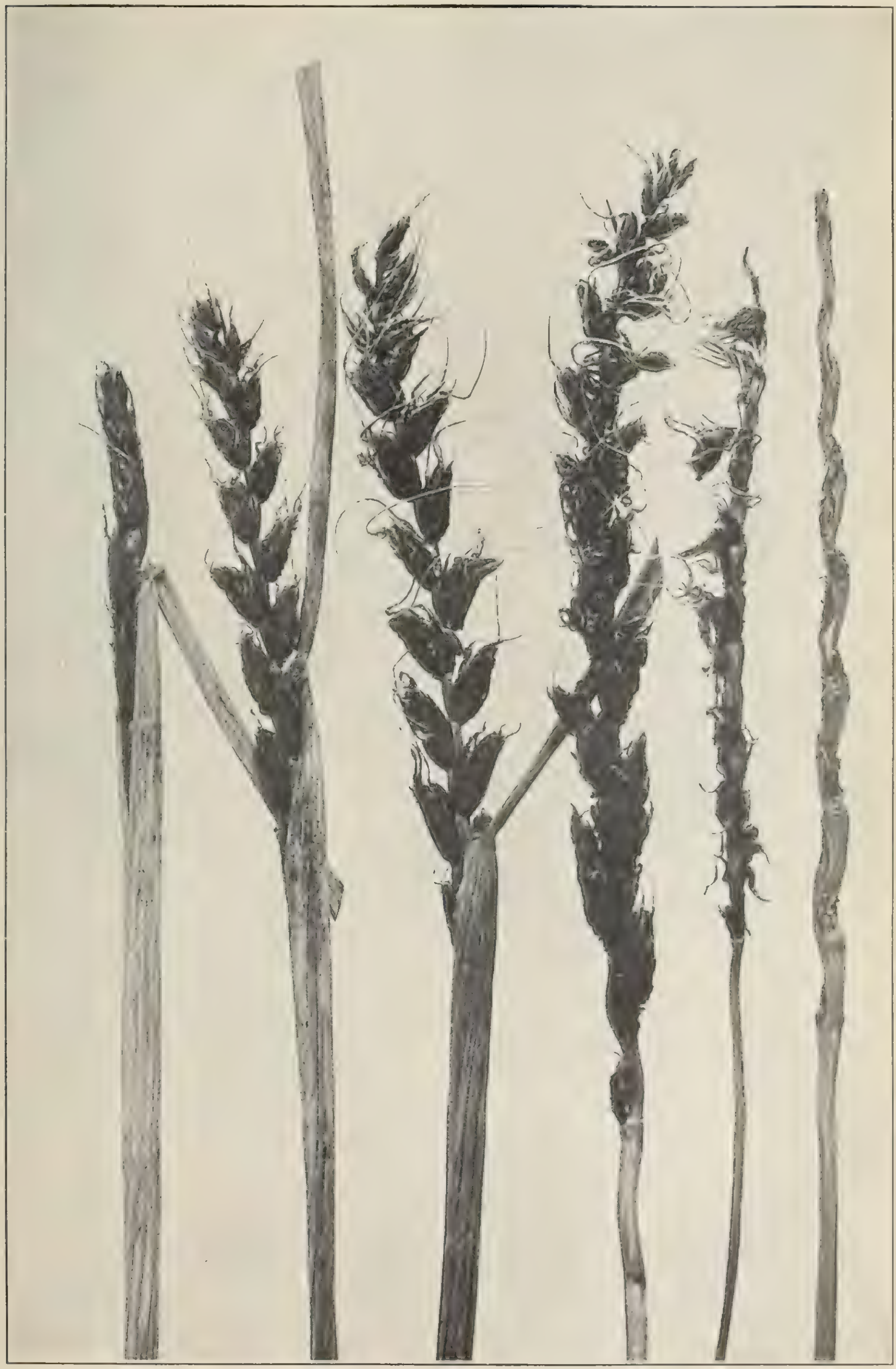
HEADS OF WHEAT AND BARLEY, SHOWING THE COMMON SMUTS.



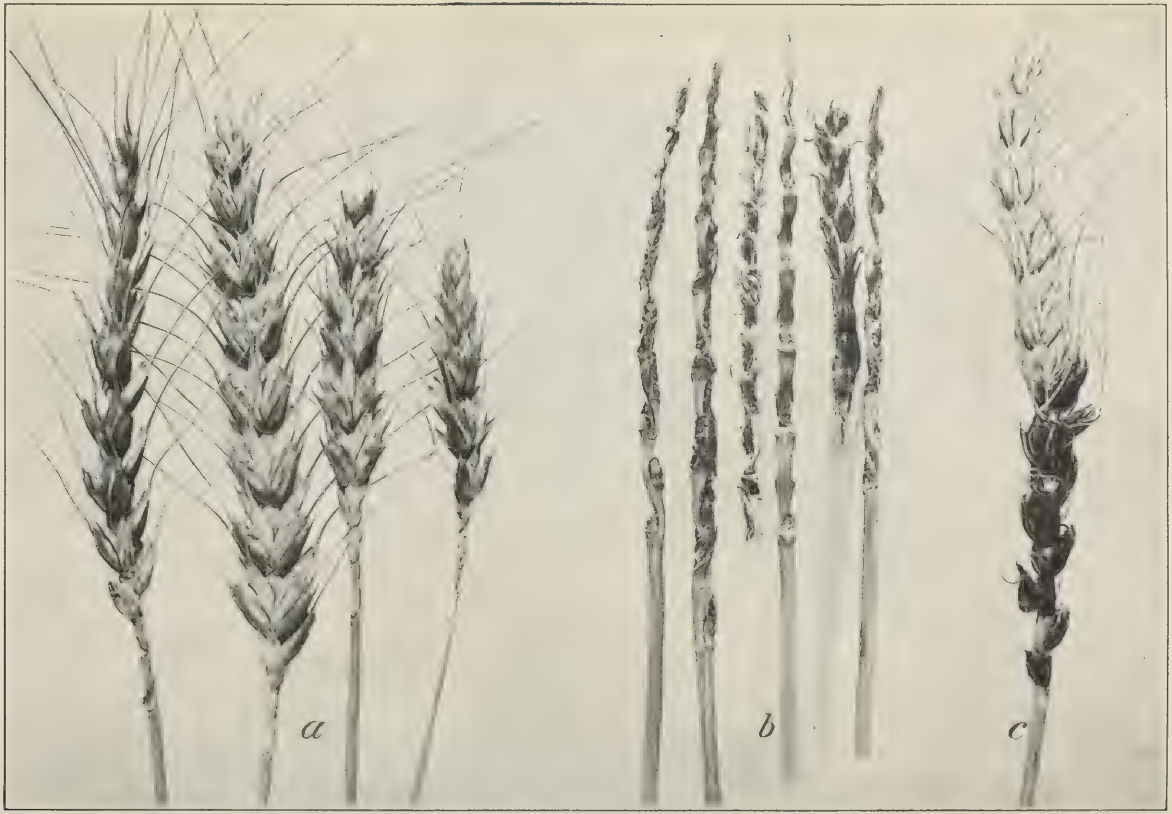
LOOSE SMUT OF BARLEY, SHOWING THE VARIOUS STAGES IN THE DEVELOPMENT OF A SMUTTED HEAD.



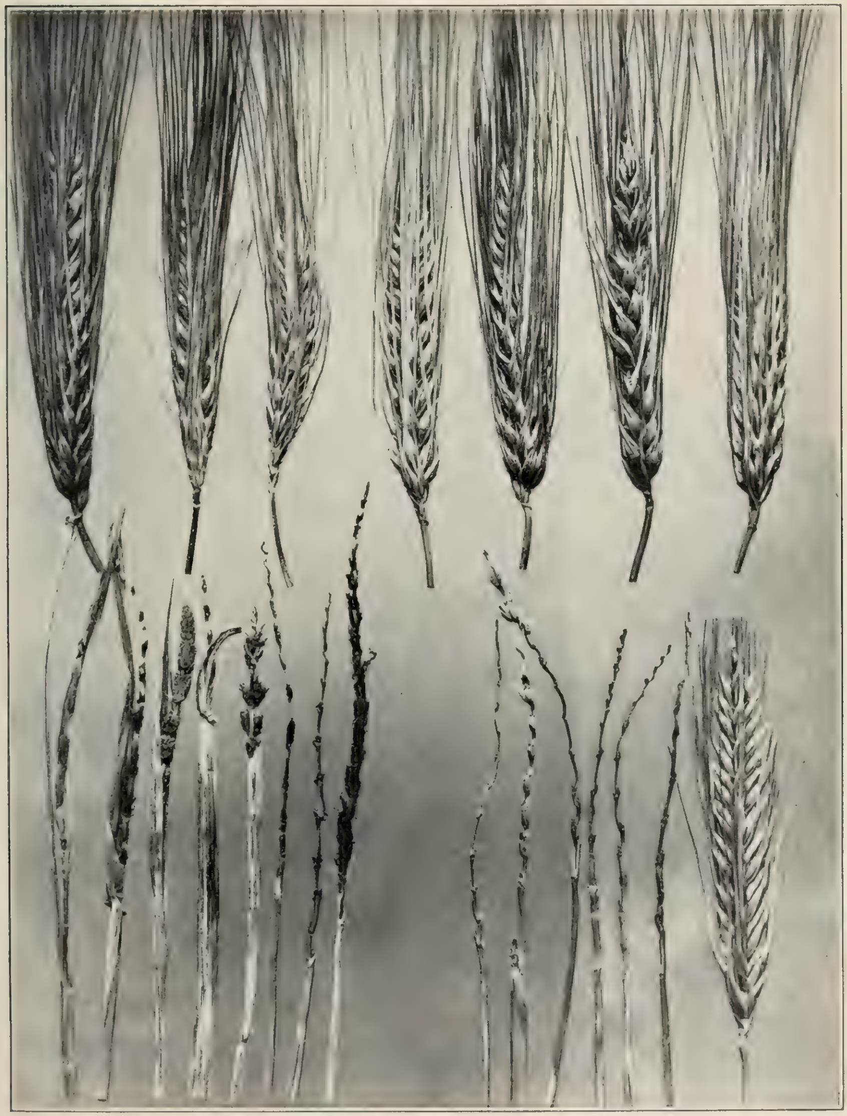
LOOSE SMUT OF BARLEY, SHOWING VARIOUS MANIFESTATIONS OF SMUT.



LOOSE SMUT OF WHEAT, SHOWING THE VARIOUS STAGES IN THE DEVELOPMENT OF A SMUTTED HEAD.



LOOSE SMUT OF WHEAT, SHOWING HEADS FROM A SOUND PLANT AND FROM A SMUTTED PLANT AND A PARTIALLY SMUTTED HEAD.



LOOSE SMUT OF BARLEY, SHOWING HEADS FROM A SOUND PLANT, A SMUTTED PLANT, AND A PARTIALLY SMUTTED PLANT.

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B. T. GALLOWAY, *Chief of Bureau.*

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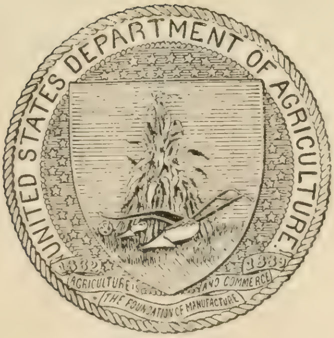

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LETTER OF TRANSMITTAL.

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BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., April 14, 1909.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 153 of the series of this Bureau, the accompanying manuscript, entitled "Seeds and Plants Imported During the Period from October 1 to December 31, 1908: Inventory No. 17; Nos. 23745 to 24429."

This manuscript has been submitted by the Agricultural Explorer in Charge of Foreign Seed and Plant Introduction with a view to publication.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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SEEDS AND PLANTS IMPORTED DURING THE PERIOD FROM OCTOBER 1 TO DECEMBER 31, 1908: INVENTORY NO. 17; NOS. 23745 TO 24429.

INTRODUCTORY STATEMENT.

It has been the custom for some time to mention in the introductory statement a few of the new arrivals which seem to be worthy the particular attention of the interested plant breeders and experimenters throughout the country. This does not mean that they will in the end prove the most valuable, for often the promising introductions are "dead failures," while those which come in like poor emigrants with scarcely a letter of introduction frequently crop up later somewhere in the country as new and valuable cultivated plants.

Those who are interested in the remarkable Chinese vegetables, whose possibilities have not at all been tested as they should be in this country, will find Mr. Meyer's collection, which he brought back personally from Peking, a most interesting one (No. 23932 and following). There can be little doubt that the Chinese restaurants which are scattered all over the country are creating a taste among Americans for these new vegetables, and the next step in their introduction will be their culture on a small scale to supply the growing demand of these restaurants.

Mr. W. T. Swingle has called attention to the possibilities of the Indian bael fruit (No. 23745), both as a possible new fruit which is prized in India and as a dry-land stock for the orange, and living plants of it have been secured.

Through Mr. Pink, a plant breeder of Queensland, a new raspberry has been secured which he claims has already become a favorite in Australia (No. 23478).

The Florida and California growers of the fruiting hedge plant Carissa will be interested in the newly secured species from Calcutta (No. 23750).

A new green-manure legume from Sao Paulo, Brazil, is highly recommended by Professor Hart (No. 23751).

A large collection of beans, cowpeas, squashes, field peas, and garbanzos and some remarkable hard-stemmed bamboos, which are quite different from the ordinary oriental bamboos, have been sent by Mr. Husbands (No. 23755 and following; No. 24211 and following; No. 24358 and following).

A number of additions to the strains or varieties of alfalfa have been made from Peru, Australia, Spain, and Chile. These are eagerly tried by the experts of the Department, who recognize the great possibilities which lie in any strain of this important plant which may fit into one of the many special conditions in the country.

A collection of seed from grasses representing the best grazing species on the veldt of Rhodesia (No. 23920 and following) will be tested by the agrostologist of the Department.

Mr. Meyer's collection of Chinese hollyhocks, prince's-feathers, morning-glories, four-o'clocks, balsams, Chinese pinks, marigolds, garden asters, etc., may have something of decided interest in it for American florists (No. 23995 and following).

A number of Syrian pomegranates from Sidon have come in for the experiments of the specialist of the Department, who is showing the possibilities of this fruit in America, which has so far been neglected by Americans.

A wild gooseberry from an altitude of 10,000 feet, which is used as a hedge plant in the Szechuan Province of central China, and a wild strawberry of good flavor from the same locality have been secured by Mr. Wilson, of the Arnold Arboretum (Nos. 24156 and 24165).

Two wild and possibly valuable dahlias from Mexico were sent in by Doctor Rose for the dahlia breeders (Nos. 24168 and 24169).

The Bahia Navel orange has been reimported by Consul Demers direct from Bahia, scions being taken from trees that were grafted on the "Laranja da terra" which are said to yield better fruits than those grafted on the "Laranja tanga," two different stocks in use there.

A distinct variety of the Para grass which has been so valuable in Texas has been secured from southern Brazil for trial in comparison with that already introduced (No. 24402).

A collection of Stizolobium, or velvet beans, has been sent on request by Director Treub, of the Royal Botanic Gardens of Java, for the purpose of comparison with the recently introduced species from the Philippines which has proved so unusually promising.

The inventory covers a period of three months, from October 1 to December 31, and includes 685 separate introductions. The preparation of the manuscript has been in the hands of Miss Mary A. Austin, and the determinations of the material have been made by Messrs. W. F. Wight and H. C. Skeels, of the Office of Taxonomic and Range Investigations.

David Fairchild,
Agricultural Explorer in Charge.

Office of Foreign Seed and Plant Introduction,
Washington, D. C., April 3, 1909.

INVENTORY.

23745. Belou marmelos (L.) W. F. Wight. **Bael tree.**

From Savannah, Ga. Presented by Rev. Henry W. Hale. Received October 6, 1908.

See No. 22957 for description.

23746. Bambos senanensis Franch. et Sav. **Bamboo.**

From Japan. Presented by the Yokohama Nursery Company, Yokohama, Japan. Received October 2, 1908.

"*Misuzudake.* This is a dwarf variety of bamboo growing wild at high altitude in the province of Shinshiu." (*Yokohama Nursery Company.*)

23747. Mangifera indica L. **Mango.**

From Amritsar, Punjab, India. Procured from Mr. Theo. C. Maller. Received October 8, 1908.

Maller.

23748. Rubus rosaefolius ♀ × ellipticus ♂. **Raspberry.**

From Wellington Point, Brisbane, Queensland, Australia. Presented by Mr. James Pink. Received October 3, 1908.

"*Federal.* This is a cross between a variety received from Japan under the name of *Rubus flava* (=*R. ellipticus* Sm.), a strange growing plant, but useless commercially; this was the male parent, the mother parent being our native *Rubus rosaefolius* Sm. I crossed the plants in 1901. I did not think much of the product till the present season, when the variety has improved much by cultivation and has become a great favorite in the markets; in fact, it is the only Rubus grown for commercial purposes in Queensland. The fruit is larger than the English raspberry and of a bright crimson color." (*Pink.*)

23749. Medicago sativa L. **Alfalfa.**

From Lima, Peru. Presented by Señor Ignacio La Puente, through Mr. Charles J. Brand. Received July 10, 1908.

"Señor La Puente states that this seed is from the latest crop, that it emanates from the Department of Supe, and that the variety is one greatly prized in the coast country of Peru. Kaerger in his paper 'Die Landwirthschaft in Peru' states that in the coastal region of Peru, alfalfa, strange to say, will not grow in the height of summer (January and February), even though it be given ample irrigation. The esteem in which this variety is held may bear some relation to this fact." (*Brand.*)

23750. Carissa carandas L.

From Sibpur, Calcutta, India. Presented by Mr. W. W. Smith, acting superintendent, Royal Botanic Garden. Received October 1, 1908

23750—Continued.

"A dense, spiny shrub or sometimes a small tree, flowering from February to April (in India) and bearing a small fruit which is grape-green when young, changing to white and pink as it approaches maturity, and black when fully ripe. The fruit ripens from July to August.

"In India the fruit is made into pickle just before it is ripe, and is also employed in tarts and puddings. For these purposes it is said to be superior to any other Indian fruit. When ripe it makes a very good jelly equal to the red currant, for which purpose it is cultivated in the gardens owned by Europeans. The shrubs are also grown for hedges." (*Watt, Dictionary of Economic Products of India, 2 : 165. 1889.*)

"This ought to be of value in southern California where the red currant does not thrive." (*W. F. Wight.*)

23751. STIZOLOBIUM sp.

From Piracicaba, Sao Paulo, Brazil. Presented by Prof. J. William Hart, director, Agricultural College. Received September 14, 1908.

"I think this will prove one of our best legumes for green manuring." (*Hart.*) Grown from No. 21094. See this number for description.

23752 and 23753. MEDICAGO SATIVA L. **Alfalfa.**

From Australia. Presented by Mr. Elwood Mead, The State River and Water Supply Commission, Treasury Gardens, Melbourne, Australia, who procured the seed from F. H. Brunning, Pty. Ltd., Melbourne, Australia, at the request of Mr. Charles J. Brand. Received August, 1908.

Seed of each of the following:

23752. *Hunter River* or *Tamworth.* "This comes from the chief alfalfa-growing district in Australia." (*Mead.*)

23753. *Queensland.* "This alfalfa was grown at Clifton on the Downs by a man who is well up in the saving of a good strain of broadleaf alfalfa." (*Brunning.*)

23754. EDGEWORTHIA GARDNERI (Wall.) Meisn. **Mitsumata.**

From Yokohama, Japan. Procured from the Yokohama Nursery Company. Received October 12, 1908.

See No. 9162 for description.

23755 to 23869.

From Chile. Received from Mr. José D. Husbands, Limávida, Chile, October 7, 1908.

The following seeds and plants, descriptive notes by Mr. Husbands; native names quoted:

23755 to 23759. PHASEOLUS VULGARIS L. **Bean.**

23755. Extra fine. Grown dry in sandy soil, coast.

23756. "*Amidon*" (starch). Extra good.

23757. "*Coscorones Baya Pintado.*" Extra good class for any use. Good land.

23758. "*Bayas Chico*" (small bay).

23759. "*Mendez.*" Grown in black clay, irrigated.

23760. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

"*Corregüela.*" Very good and extra prolific at the tops or points.

24755 to 23869—Continued.

23761 to 23834. PHASEOLUS VULGARIS L. **Bean.**

23761. Name unknown. Extra fine class.

23762. "*Coscorones Baya.*" Extra fine class. Prolific.

23763. "*Entrometido Chico*" (small meddler). A commercial bean largely sown but not of the best quality. Stands droughts and grows in any soil.

23764. "*Blanco.*" Extra good for any purpose.

23765. "*Barroso*" (muddy). Extra good class.

23767. Extra early.

23768. "*Aparcido*" (found). White pods.

The above (S. P. I. Nos. 23755 to 23768) grown by irrigation.

23769 to 23786. Grown dry about 10 miles from the sea.

23769. "*Rosilos de Reigo.*" Largely sown.

23770. "*Rosilos de Rulo.*" Largely sown.

23771. "*Poratos Lacre*" (red beans). Grown dry in poor sandy soil.

23772. Grown in poor light soils.

23773. White. Extra fine class; grown in poor soil.

23774. Yellow. Grown dry on coast.

23775. Extra good class; grown in poor soil.

23776. Extra fine; grown in sandy soil.

23777. "*Bayas Chico*" (small bay). Grown in poor soil. Seed mixed.

23778. "*Mantequilla*" (butter). Extra superfine class.

23779. Yellow and red. Grown in poor sandy soil.

23780. "*Burro Claro*" (light-colored donkey). Extra good class; grown in poor soil.

23781. Light yellow, medium size. Grown in poor soil.

23782. Cream and black. Medium quality; grown in bad soil.

23783. "*Burro Oscuro*" (dark donkey). Extra good class; grown in poor soil.

23784. Light yellow. Grown dry on the coast.

23785. Small, white, good; grown in bad soil.

23786. "*Amarillos Chico*" (small yellow). Grown in poor soil.

23787 to 23828. Stringless or garden beans grown by irrigation.

23787. Mixed, grown in clay soil.

23788. Round, yellow.

23789 and 23790. (No description.)

23791. Very good and productive.

23792 to 23795. (No description.)

23796. Brown.

23797. Good class.

23798 and 23799. (No description.)

23800. "*Palo*" (stick).

23755 to 23869—Continued.

23761 to 23834—Continued.

23787 to 23828—Continued.

23801. Good sort.

23802. "*Siete Semanas*" (seven weeks). Good.

23803. (No description.)

23804. "*Overos.*" Good.

23805. Early and very prolific.

23806. Extra early and prolific.

23807. Can be grown dry in loose, sandy soil.

23808. Can be grown dry in loose, sandy soil.

23809 to 23811. (No description.)

23812. A good class.

23813 to 23815. (No description.)

23816. Geese beans.

23817 to 23819. (No description.)

23820. Green color. Rare.

23821 to 23827. (No description.)

23828. An extra early bean; grows two crops per year when irrigated.

23829 to 23834. Stringless or garden beans from the coast; grown dry.

23829. "*Trigo*" (wheat). Extra superfine quality. Prolific.

23830. Extra prolific.

23831. "*China Lejos Grande.*" Grown dry in any soil.

23832. All sorts. Grown dry in any soil.

23833. Grown in poor, sandy soil.

23834. No name.

23835 and 23836. PHASEOLUS COCCINEUS L. **Scarlet runner bean.**

23835. Pink.

23836. "*Parjares.*" Said to be different from other white classes. Grown by marine dews only.

These beans grow in any soil without losing their size or merit. The difference between suitable good and bad land sowing is chiefly in the greater or lesser yield.

23837 to 23840. CUCURBITA sp. **Squash.**

23837. Extra good class.

23838. Extra good; sweet, fiberless, prolific, meat solid; small cavity for seeds.

23839. A very good class.

23840. Pinkish color, large, thick flesh, sweet, mealy, prolific, good.

23841. CUCURBITA MAXIMA Duch. **Squash.**

Extra good class.

23842 to 23844. CUCURBITA sp. **Squash.**

23842. Black skinned; thick, sweet, fiberless flesh; extra good.

23755 to 23869—Continued.

23842 to 23844—Continued.

23843. Extra good class.

The above (S. P. I. Nos. 23837 to 23843) grown by irrigation.

23844. Not as good as watered sorts.

23845. CUCURBITA MAXIMA Duch. **Squash.**

Good class; sweet, thick, fiberless meat.

The above (S. P. I. Nos. 23844 and 23845) grown dry near the coast. The squashes grown dry are of little merit when compared with the irrigated sorts.

NOTE.—"These squashes listed as *Cucurbita* sp. are probably *Cucurbita maxima* Duch., but not determinable until grown. These seeds are very different from any squash seeds found heretofore."—(*W. F. Wight.*)

23846 to 23851. PISUM ARVENSE L. **Field pea.**

The following are common field peas grown dry in poor, sandy soil:

23846. A large, extra sweet field pea; fall sown.

23847. The most ordinary sort.

23848. The most ordinary sort; seed mixed.

23849. Ordinary white peas; grown in poor soil.

23850. Common peas; grown in poor soil.

23851. Grown in bad soil.

23852 to 23855. CICER ARIETINUM L. **Chick-pea.**

23852. "*Garbanzos Chico*" (small). Grown dry in red clay.

23853. "*Garbanzos Grande*" (large). Grown dry in loose soil near coast.

23854. "*Garbanzos Negro*" (black). Grown dry in red clay.

23855. "*Garbanzos Grande*" (large). Grown dry in clay soil.

These peas (S. P. I. Nos. 23846 to 23855) are not samples of the many best classes that can be had elsewhere in Chile, but are samples of the common hardy sorts that grow dry on hills whose soil is so poor that no vegetation of any kind exists except a few stunted red oaks. These are sown broadcast upon the ground and plowed in.

23856 and 23857. LATHYRUS SATIVUS L. **Grass-pea.**

23856. "*Chicharos Grande*" (large). Grow dry in any soil. Grow larger or smaller according to the quality of the soil.

23857. "*Chicharos Chico*" (small). Grow dry in any soil. Always small no matter what class of soil.

23858 and 23859. LENS ESCULENTA Moench. **Lentil.**

23858. "*Lentejas Rosillos*" (gray lentil). Grown dry in bad soil.

23859. Common lentils. Grown dry in bad soil.

23860. PISUM SATIVUM L. **Pea.**

"*Arvejones.*" A class of stringless peas. Both peas and pods are eaten.

23861. HORDEUM VULGARE L. **Barley.**

"*Poda.*" Grain head has 8 rows. This is mixed with other classes having 2, 4, and 6 rows of grain, respectively. The 4-rowed is called "*Caballuna.*"

23862. HORDEUM sp. **Barley.**

Common class grown in damp land; is discolored by the moisture of heavy dews.

23755 to 23869—Continued.

23863. JUGLANS NIGRA L. **Black walnut.**

Black walnuts long grown dry in Chile, but are not native of the country.

23864. CHUSQUEA VALDIVIENSIS E. Desv. **Bamboo.**

Colihue or bamboo. Solid stem, grows about 20 to 25 feet high, slightly drooping, small scant foliage, short joints, very tough, grows dry on any poor soil, extra hardy.

23865. CHUSQUEA VALDIVIENSIS E. Desv. **Bamboo.**

Colihue or bamboo. Solid stem, grows straight from 25 to 30 feet high, abundance of small, long-leaved foliage, a good industrial class, grows dry on any arid soil, extra hardy.

23866. ARUNDO DONAX L. **Giant reed.**

Colihue or bamboo. Hollow stem, grows erect, about 25 to 30 feet high; roots extend on top of the ground. From top to bottom has a rank leaf growth, like corn leaves, extending from two opposite sides; the second year it throws out branches. A valuable commercial class, extra hardy, resists droughts. This was found growing on pure sand which dries to a powder eight months of the year.

All of the above (S. P. I. Nos. 23864 to 23866) are from the Coast Cordilleras about 35 to 40 miles from the sea, are readily eaten by all animals; extra hardy.

23867. CHUSQUEA QUILA (Poir.) Kunth. **Bamboo.**

Quila. A long-leaf-stem class about 20 feet long; grows drooping.

23868. CHUSQUEA QUILA (Poir.) Kunth. **Bamboo.**

Quila. A drooping class whose short leaves grow in bunches close to the stem from each joint. When the leaves are eaten they quickly grow again and also sprout anew. A good forage class. From 10 to 20 feet long.

23869. CHUSQUEA QUILA (Poir.) Kunth.

Quila. Similar to S. P. I. No. 23867 in leaf; plant somewhat dwarfed; grows from 6 to 12 feet long.

All of the above (S. P. I. Nos. 23867 to 23869) are from the Coast Cordilleras about 40 miles from the sea, are extra hardy and grow dry in poorest arid soils.

23870. RUBUS PANICULATUS Smith. **Raspberry.**

From Jaunsar District, Chakrata U. P., India. Presented by Mr. H. G. Billson, Deputy Conservator of Forests, requested by Mr. David Fairchild at the suggestion of Mr. Henry M. Dumbleton, Victoria, British Columbia. Received October 13, 1908.

"This 'blue raspberry' grows sparingly in the forests in the Jaunsar District. The bush is small and trailing; the fruit is about the size of a logan berry, but with a beautiful blue bloom, and is excellent eating." (*Dumbleton.*)

"This raspberry is the '*Kala Anchu.*' It grows best below 6,000 feet and likes damp, shady ravines." (*Billson.*)

23871. MEDICAGO SATIVA L. **Alfalfa.**

From Elche, Spain. Presented by Dr. L. Trabut, government botanist, Algiers, Algeria, through Mr. Charles J. Brand. Received February 14, 1908.

"This sample of alfalfa was grown at Elche, Spain, where Doctor Trabut personally collected it. It has unusually large leaves and Doctor Trabut regards it as being distinct from Algerian alfalfa." (*Brand.*)

23872 to 23881.

From Paris, France. Presented by Mr. E. Tisserand, Minister of Colonies, Jardin Colonial. Received October 4, 1908.

The following plants:

23872 to 23874. Musa paradisiaca L. **Banana.**

23872. *Chec Chwea* (Cambodia).

23873. *Primitivo* (Colombia).

23874. *Gabou* (Réunion).

23875. Musa cavendishii Lamb. **Banana.**

Sweet (New Caledonia).

23876 and 23877. Colocasia esculenta (L.) Schott.

23876. Green.

23877. Violet.

23878. Bombax macrocarpum (Cham. & Schlecht.) Schum.

23879. Passiflora laurifolia L.

23880. Passiflora sp.

(Mexico.)

23881. Amorphophallus bulbifer (Roxb.) Blume.

23882. Garcinia cornea L. (?)

From Buitenzorg, Java. Presented by Dr. M. Treub, director, Department of Agriculture. Received October 15, 1908.

"The *Garcinia cornea* L. is a small tree, with horizontal branches; leaves, leathery, shining. Fruit the size of a small orange, bright red; seeds inclosed in a white, juicy, very acid aril." (*Hooker, Flora of British India.*)

"An evergreen tree; yields an inferior kind of gamboge; wood brown, heavy, of a coarse unequal fiber, hard, rather close grained." (*Watt, Economic Products of India.*)

"Imported for use in solving the mangosteen problem." (*Fairchild.*)

23894 and 23895. Rubus chamaemorus L.

From Harrington Harbor, Canadian Labrador. Presented by Miss Edith Mayon, Deep Sea Mission Hospital. Received October 17, 1908.

"Plants and fruits of what is locally called the *Bake apple;* it resembles a yellow raspberry in color and size, tastes of honey and bananas mixed, grows in moist ground on a plant 4 inches high; the flower is white. It is very hardy, for our winters are long and severe, the surface of the ground is still frozen (May 26) and there is snow in all the hollows and shady places." (*Mayon.*)

23896. Medicago sativa L. **Alfalfa.**

From Lima, Peru. Presented by Señor Ignacio La Puente, through Mr. Charles J. Brand. Received September, 1908.

"This seed probably originated in the vicinity of Supe, in the coastal plain region of Peru." (*Brand.*)

23897. Cryptocarya rubra (Mol.) Skeels. (Peumus rubra Mol. Sagg. Chil. 185. 1782.) (Cryptocarya peumus Nees.)

From Coronel, Chile. Presented by Mr. Teodoro Finger, Estación Colico, through Mr. O. W. Barrett. Received October 20, 1908.

23897—Continued.

"A beautiful Chilean tree, persistent leaves, produces a small pink fruit of the size of a small olive; natives eat the fruit after boiling it. Very ornamental when fruits are ripe. Requires wet soil, can stand frost, grows best in valley protected from wind, in forests." (*Finger.*)

23899. UVARIA RUFA (Dun.) Blume.

From Pampanga, Philippine Islands. Presented by Mr. William S. Lyon, Gardens of Nagtajan, Manila, P. I. Received October 20, 1908.

"Small evergreen fruit tree, from sea level up to 2,000 feet, lat. 10½° S. to 16° N. Fruits oblong (5 cm. × 3 cm.) in grape-like clusters, 10 to 30 berries. These are edible and fairly palatable. Intense vermilion red, making tree in fruit very attractive." (*Lyon.*)

23900. ACTINIDIA ARGUTA (S. & Z.) Planch. (?)

From Marblehead, Mass. Received October 21, 1908.

"From a 20-year-old vine on the place of Mr. Charles N. Parker, Marblehead, Mass. This vine has borne fruit regularly since it was 8 to 9 years old, and I saw fruit on it. There can be no doubt, therefore, that it is the female variety and a good bearer. The fruit is of delicate flavor." (*Fairchild.*)

23901. CECROPIA PELTATA L.

From Kingston, Jamaica. Presented by Mr. W. Harris, superintendent, Public Gardens, Department of Agriculture, through Mr. P. J. Wester, Subtropical Garden, Miami, Fla. Received October 23, 1908.

"A variety of the urticaceous quick-growing Cecropias with edible, not very well-flavored fruits; available as a shade tree, abundant in the warmer valleys and rain-forests of Mexico. Introduced for testing at the Subtropical Garden, Miami, Fla." (*Chisolm.*)

23902. MEDICAGO SATIVA L. **Alfalfa.**

From Peru. Presented by Mr. T. F. Sedgwick, Lima, Peru, for Mr. C. V. Piper. Received October 6, 1908.

San Pedro.

23913. PINUS DENSIFLORA Sieb. & Zucc. **Pine.**

From near Tungling, Chihli, China. Received through Mr. Frank N. Meyer, agricultural explorer, summer of 1908.

"(No. 1172a, Nov. 29–08.) This pine grows all over northern China and seems to vary a great deal." (*Meyer.*)

23914. NICOTIANA TOMENTOSA Ruiz. & Pav.

From Erfurt, Germany. Purchased from Messrs. Haage & Schmidt, at the request of Mr. A. D. Shamel. Received October 26, 1908.

"I know very little about this species, but it was purchased at Mr. George W. Oliver's suggestion in connection with our work in hybridizing tobacco. It is a very large species, with large leaves and tall stem. At present it is mainly of scientific interest, but on account of its leaf size would probably be valuable as a parent for a composite cross in regions where the yield of tobacco is the main consideration." (*J. B. Norton.*)

23915. Carica papaya L. **Papaw.**

From Singerton, near Hectorspruit, Transvaal, South Africa. Presented by Prof. J. Burtt Davy, government agrostologist and botanist, Transvaal Department of Agriculture, Pretoria, Transvaal, South Africa. Received October 26, 1908.

"These seeds were procured at an altitude of 1,200 feet, subtropical climate and rather dry. The flavor was excellent, and though I can not say that it will prove superior to that of some grown in the States, it is worth trying." (*Davy.*)

23916. Phaseolus lunatus L.

From Rio Mucury, Brazil. Presented by Mr. Fred Birch, Casa do Correio, Theophilo Ottoni, Minas Geraes, Brazil. Received October 26, 1908.

"We have become acquainted with a remarkable legume here. It is a vine which grows to a length of 40 to 50 feet or more, straggling over 3 or even 4 trees of the size of orange trees. It bears its pods of (we have heard) 'most delicious' beans for 3 years in succession, and is very accommodating to a planter who is hard pressed for time, for the beans will remain good on the vine for a long time after they are ripe. Wherever the summer is hot enough, as in Florida, and there is no frost, it would thrive, I think. The only thing it wants is a fertile soil and trees to climb over. One plant will yield a large quantity of beans; on one I saw there were, I should think, 100 pods. The beans are so good that one friend said 'Everyone is mad after them.'" (*Birch.*)

23917. Carica sp. Wild papaw.

From Upper Rio Mucury, Brazil. Presented by Mr. Fred Birch, Casa do Correio, Theophilo Ottoni, Minas Geraes, Brazil. Received October 26, 1908.

"Seed of a tree called the 'wild mamau' i. e., wild papaw, as it (the fruit) greatly resembles a papaw in shape. The tree has a large, thick, quickly tapering trunk about 2 feet 6 inches in diameter at the base and a comparatively small head, so that one is quite a remarkable object in the landscape; naturally it only grows in rich forest soil and usually on a slope. Whenever the natives find a young one in the forests they always take it home and plant it near their door, as it is in great repute as a medicine tree. They firmly believe that there is no finer remedy for anaemia than its fruits. Do not forget that this fruit is a somewhat difficult one to eat. It has the strange effect of scratching the tongue and sides of throat so much as to draw blood. Whether this is due to minute spicules of flinty substance or a corrosive property of the juice I have not yet found out, but I found that when my mouth and throat had become hardened by eating 3 or 4 I could take them with impunity. The largest fruits are quite small compared to the cultivated papaw, being only 4 inches long and 1½ inches in diameter, of a bright orange color, with tender skin and of luscious appearance. The foliage is very ornamental, like horse-chestnut in miniature; it is quite striking and unlike every other forest tree here." (*Birch.*)

23918 and 23919.

From New York. Presented by Mr. George V. Nash, head gardener, New York Botanical Garden, Bronx Park, New York City, at the request of Mr. Frank N. Meyer. Received October 26, 1908.

Seed of each of the following:

23918. Berberis amurensis Rupr.

"Stock secured from Biltmore Nursery in 1903." (*Nash.*)

"A densely branched shrub 4 to 5 feet high, quite variable, as seen in the New York Botanic Garden. At the time of my visit, early in September,

23918 and 23919—Continued.

1908, the bushes were most heavily loaded with bright scarlet berries, making them extremely ornamental. Mr. Nash said that, in his expectation, this particular variety may even replace *B. thunbergii* on account of its early and ornamental fruiting capacities." (*Meyer.*)

23919. LIGUSTRUM sp.

"This came to us as *Ligustrum massaloungeanum.*" (*Nash.*)

"A remarkable privet, with rather large leaves, of dark green, glossy appearance. Grows very densely branched and is of somewhat fastigiate habit. May be of use in hybridization work when attempts are being made to create a privet combining the hardiness of *L. ibota* with the leaf characteristics of *L. ovalifolium.*" (*Meyer.*)

23920 to 23929.

From South Africa. Presented by Mr. W. C. S. Paine, through Mr. W. D. Warne, Cecil Hotel, Umtali, Rhodesia, South Africa. Received July 20, 1908.

Seed of each of the following:

23920. ERAGROSTIS sp.

23921. ERAGROSTIS sp.

23922. BAMBOS (?).

23923. TRISTACHYA BISERIATA Stapf.

23924. TRISTACHYA REHMANNI Hack.

23925. POGONARTHRIA FALCATA (Hack.) Rendle.

23926. PANICUM SERRATUM (Thunb.) R. Br.

23927. THEMEDA FORSKALII Hack.

23928. ANDROPOGON RUFUS (Nees) Kunth. (?)

23929. ANDROPOGON PLEIARTHRON Stapf. (?)

"The above selection I made from veldt cattle favor, although I can not claim to state with any authority the specific value of the grasses. The soil is dioritic, a sandy loam, varying in color from pinkish red, deep red, and chocolate." (*Paine.*)

23930 to 24113.

From China. Brought by Mr. Frank N. Meyer, agricultural explorer, direct from China. Turned over to this office to be numbered for distribution October, 1908.

The following seeds:

23930. ASTRAGALUS SINICUS L.

"(No. 986a, May 31, 1908.) A few seeds of a most important leguminous plant, which is grown and plowed under for manure on low-lying rice fields. Sown in the autumn in rows or broadcast, plowed under in May or early June just before the rice has to be planted. According to the Chinese, is not fit as a cattle food. Collected on some bamboo boxes while en route to America aboard S. S. *Ashtabula*, the soil coming from near Hangchow, Chekiang, China." (*Meyer.*)

23931. MEDICAGO DENTICULATA Willd. **Bur clover.**

"(No. 987a, May 28, 1908.) A yellow-flowered bur clover, grown by the Chinese on low-lying rice fields as a winter crop, to be plowed under in spring, serving as manure. Mostly sown in autumn in rows or broadcast after coming up by itself. The cattle feed eagerly upon this crop. Collected on some

23930 to 24113—Continued.

bamboo boxes aboard S. S. *Ashtabula*, while en route to America, the soil coming from near Hangchow, Chekiang, China." (*Meyer.*)

23932. LAGENARIA VULGARIS Ser. **Gourd.**

From Chinanfu, Shantung, China. "(No. 988a, September, 1908.) A small-fruited ornamental gourd, out of which the Chinese manufacture little carved vessels for ornaments." (*Meyer.*)

23933. CUCURBITA sp.

From Spask, eastern Siberia. "(989a, Oct. 20, 1906.) An ornamental gourd, producing remarkable quaint fruits which vary in all ways. Given to me by a Russian farmer." (*Meyer.*)

23934. CUCURBITA PEPO L. **Squash.**

From Pangshan, Chihli, China. "(No. 990a, November, 1907.) A large turban-shaped gourd, one part of which is orange-yellow colored while the other part is green with orange stripes. Quite ornamental." (*Meyer.*)

23935. CUCUMIS SATIVUS L. **Cucumber.**

From Peking, Chihli, China. "(No. 991a, Mar. 25, 1908.) A Chinese cucumber called *Huang kua;* grown on trellises in the open ground." (*Meyer.*)

23936. CUCUMIS MELO L. **Muskmelon.**

From Peking, Chihli, China. "(No. 992a, Mar. 25, 1908.) A small muskmelon; grown on light sandy soil. Chinese name *Hsien kua.*" (*Meyer.*)

23937. LUFFA CYLINDRICA (L.) Roemer.

From Peking, Chihli, China. "(No. 993a, Mar. 25, 1908.) A dishrag gourd, the tender young fruits of which are eaten by the Chinese. Chinese name *Shi kua.*" (*Meyer.*)

23938. BENINCASA CERIFERA Savi. **Gourd.**

From Peking, Chihli, China. "(No. 994a, Mar. 25, 1908.) A gourd eaten by the Chinese. Chinese name *Tung kua.*" (*Meyer.*)

23939. ACTINOSTEMMA sp.

From Peking, Chihli, China. "(No. 995a, Mar. 25, 1908.) A very rare cucurbitaceous plant, called in Chinese *Ly kua tze.*" (*Meyer.*)

23940 to 23945. LAGENARIA VULGARIS Ser. **Gourd.**

From Peking, Chihli, China. (Mar. 25, 1908.)

23940. "(No. 996a.) Chinese name *Yang hu lu.*"

23941. "(No. 997a.) Chinese name *Yoh hu lu.*"

23942. "(No. 998a.) Chinese name *Ko ko hu lu.*"

23943. "(No. 999a.) Chinese name *Shoo yar yow hu lu.*"

23944. "(No. 1000a.) Chinese name *Ta yar yow hu lu.*"

23945. "(No. 1001a.) Chinese name *Ta pauw hu lu.*"

"The above Lagenarias are grown by the Chinese on trellises in their gardens; the very young fruits are often eaten stewed as a vegetable; the old, well-ripened gourds are used as bottles for oil, wine, and water, or when cut in two lengthwise are used for water dippers and for pans in which to keep things. The large round gourds serve the country Chinese for the same purpose as our drawers in cupboards do, viz, to keep things stored in; and lastly these Lagenaria seeds are often boiled with salt and sold as an appetizing delicatesse." (*Meyer.*)

23930 to 24113—Continued.

23946 to 23952. CUCURBITA PEPO L.

From Peking, Chihli, China. (Mar. 25, 1908.)

23946. "(No. 1002a.) Chinese name *San kua.*"

23947. "(No. 1003a.) Chinese name *Nan kua.*"

23948. "(No. 1004a.) Chinese name *Tau nan kua.*"

23949. "(No. 1005a.) Chinese name *Tchoo tze kua.*"

23950. "(No. 1006a.) Chinese name *Ba loeng woo kua.*"

23951. "(No. 1007a.) Chinese name *Shi bin woo kua.*"

23952. "(No. 1008a.) Chinese name *Hsi hu kua.*"

"The above numbers include pumpkins and squashes and are used by the Chinese as vegetables, either stewed or boiled. The seeds too are roasted or boiled in salted water and then dried. The plants are mostly grown between corn, sorghum, and other tall-growing crops, sometimes even on rather alkaline soil." (*Meyer.*)

23953 to 23956. DOLICHOS LABLAB L. **Bonavist bean.**

From Peking, Chihli, China. (Mar. 25, 1908.)

23953. "(No. 1009a.) Chinese name *Lung tsao pian doh.* Black colored."

23954. "(No. 1010a.) Chinese name *Tze pian doh.* Black colored."

23955. "(No. 1011a.) Chinese name *Ching pian doh.* Brown colored."

23956. "(No. 1012a.) Chinese name *Pai pian doh.* White colored."

"All the above hyacinth [bonavist] beans are grown by the Chinese against sorghum-stem fences and between sorghum and corn crops, in which case they use the stems of these last-named plants for their support. The pods when green and juicy are sliced and eaten boiled as a vegetable; the leaves when dry are boiled in soups and considered a rather expensive food." (*Meyer.*)

23957. PHASEOLUS COCCINEUS L. **Scarlet runner bean.**

From Peking, Chihli, China. "(No. 1013a, Mar. 25, 1908.) The scarlet runner is grown sparsely in northern China against fences of sorghum stems and on poles, apparently for ornament, though the fresh pods are sliced and eaten boiled and the dry beans are sometimes cooked in soups. Chinese name *Hua pian doh.*" (*Meyer.*)

23958. PHASEOLUS VULGARIS L.

From Peking, Chihli, China. "(No. 1014a, Mar. 25, 1908.) A form of garden bean, loving a rich garden soil, but being able to stand much alkali. The young pods are eaten boiled as a vegetable; the dry beans are cooked in soups. Chinese name *Yueng pian doh.*" (*Meyer.*)

23959. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

From Peking, Chihli, China. "(No. 1015a, Mar. 25, 1908.) A long string bean, the pods of which are eaten boiled as a vegetable. Has to be grown on stakes and is remarkably productive. Chinese name *Chiang doh.*" (*Meyer.*)

23960. ABRUS PRAECATORIUS L.

From Peking, Chihli, China. "(No. 1016a, Mar. 25, 1908.) The paternoster bean; grown by the Chinese for medicine and for ornament, namely, they manufacture beads and bracelets of the seeds by stringing them on strong threads. Chinese name *Yae ho hua.*" (*Meyer.*)

23930 to 24113—Continued.

23961. Ricinus communis L. **Castor oil bean.**

From Peking, Chihli, China. "(No. 1017a, Mar. 25, 1908.) The castor oil bean which is grown all over China, the oil being used for culinary purposes, viz, all the doughnuts and small cakes which the Chinese eat for breakfast are fried in it, and it seems to lose its peculiar medicinal properties after having been heated. Chinese name *Ta ma tze*." (*Meyer.*)

23962. Coix lacryma-jobi L. **Job's tears.**

From Peking, Chihli, China. "(No. 1018a, Mar. 25, 1908.) The well-known Job's tears, seeds of which are used for ornaments. Chinese name *Tsao choo tze*." (*Meyer.*)

23963 and 23964. Brassica pekinensis (Lour.) Skeels. (Sinapis pekinensis Lour.) (Brassica petsai Bailey.) **Chinese cabbage.**

From Peking, Chihli, China. (Mar. 25, 1908.)

23963. "(No. 1019a.) Chinese name *Boo to pai tsai*."

23964. "(No. 1020a.) Chinese name *Shoo pai tsai*."

"Sow the cabbages at the end of July or early in August, transplant in early September in well-worked and heavily manured soil. Do not let them suffer from lack of water. Harvest after the first heavy frost and store away in a cool, frostproof cellar. Will do especially well in the irrigated sections of the United States." (*Meyer.*)

23965. Brassica juncea (L.) Cass. **Chinese mustard.**

From Peking, Chihli, China. "(No. 1021a, Mar. 25, 1908.) Grown as an early vegetable for greens, being sown very early in spring in a well-worked, light, warm soil. Pulled up and sold in bunches; also picked for private use. Chinese name *Yi tsai*." (*Meyer.*)

23966. Brassica rapa L. **Turnip.**

From Peking, Chihli, China. "(No. 1022a, Mar. 25, 1908.) Probably a long, white spring turnip. As such, grow it in light, well-worked soil. Sow in rows as early as possible in a protected place. The turnips stewed with milk form a good dish in the early summer. Chinese name *Pien lang*." (*Meyer.*)

23967. Raphanus sativus L. **Radish.**

From Peking, Chihli, China. "(No. 1023a, Mar. 25, 1908.) A red variety. Sow in hills, distance 1½ feet apart, in early August, on well-drained soil. Harvest before heavy frost. Store in cellar for winter use. Eaten stewed like turnips. Chinese name *Tung lung hong lou ba*." (*Meyer.*)

23968 and 23969. Raphanus sativus L. **Radish.**

From Peking, Chihli, China. (Mar. 25, 1908.)

23968. "(No. 1024a.) Chinese name *Tsui lou poo* (green radish-turnip)."

23969. "(No. 1025a.) Chinese name *Hong swee lou poo* (red radish-turnip)."

"These peculiar roots are largely eaten by the Chinese as appetizers and really are very pleasing to the taste and promote digestion. Sow in early August in well-drained soil, in hills 1½ feet apart in each direction. Harvest before a heavy frost and store in cool cellars for winter use. Always eaten raw and sliced lengthwise." (*Meyer.*)

23930 to 24113—Continued.

23970. Apium graveolens L. **Celery.**

From Peking, Chihli, China. "(No. 1026a, Mar. 25, 1908.) A Chinese variety of celery, much used in soups and in various other dishes, although quite strong. May contain more of the active alkaloids than our own varieties and be of use in celery-salt manufacture. Chinese name *Hu diën mae hua.*" (*Meyer.*)

23971. Daucus carota L. **Carrot.**

From Peking, Chihli, China. "(No. 1027a, Mar. 25, 1908.) A Chinese carrot. Sow in rows in somewhat sandy though rich soil. Do not let them have any lack of water. Chinese name *Hu lou poo.*" (*Meyer.*)

23972. Coriandrum sativum L.

From Peking, Chihli, China. "(No. 1028a, Mar. 25, 1908.) A well-known herb, the young leaves of which are used by the Chinese to flavor their soups with. The seeds are also used in various kinds of candy. Chinese name *Hsien tsai.*" (*Meyer.*)

23973. Lactuca sativa L. **Lettuce.**

From Peking, Chihli, China. "(No. 1029a, Mar. 25, 1908.) A Chinese lettuce which does not form a head, but the stems get to be quite fleshy and are stewed like asparagus. Quite tasty. Chinese name *Sun tsai.*" (*Meyer.*)

23974. Beta vulgaris L. **Beet.**

From Peking, Chihli, China. "(No. 1030a, Mar. 25, 1908.) Probably a red beet root, the young leaves of which are eaten stewed and also the roots when about full grown. This is inferior to our own varieties. Chinese name *Hong pai tsai.*" (*Meyer.*)

23975. Capsicum annuum L. **Pepper.**

From Peking, Chihli, China. "(No. 1031a, Mar. 25, 1908.) A Chihli pepper grown by the Chinese partly for ornament and partly for condiments. Chinese name *Shi tze cheeow.*" (*Meyer.*)

23976. Solanum melongena L. **Eggplant.**

From Peking, Chihli, China. "(No. 1032a, Mar. 25, 1908.) An eggplant which may turn out to be more ornamental than useful. Chinese name *Chieng yen chi.*" (*Meyer.*)

23977 to 23983. Celosia argentea L.

From Peking, Chihli, China. (Mar. 25, 1908.)

23977. "(No. 1033a.) Chinese name *Hong gee kuan hua.*"

23978. "(No. 1034a.) Chinese name *Huang gee kuan hua.*"

23979. "(No. 1035a.) Chinese name *Huang shoo gee kuan hua* "

23980. "(No. 1036a.) Chinese name *Tze shoo gee kuan hua.*"

23981. "(No. 1037a.) Chinese name *Hong shoo gee kuan hua.*"

23982. "(No. 1038a.) Chinese name *Pai shoo gee kuan hua.*"

23983. "(No. 1039a.) Chinese name *Kuan shang chiar kuan.*"

"The above forms are grown by the Chinese as ornamental garden plants." (*Meyer.*)

23984 to 23988. Amaranthus spp.

From Peking, Chihli, China. (Mar. 25, 1908.)

23984. "(No. 1040a.) Chinese name *Lo lie show.*"

23985. "(No. 1041a.) Chinese name *Hong doo chuang hua.*"

23930 to 24113—Continued.

23984 to 23988—Continued.

23986. "(No. 1042a.) Chinese name *Sen doo chuang hua.*"

23987. "(No. 1043a.) Chinese name *Tze doo chuang hua.*"

23988. "(No. 1044a.) Chinese name *Pai doo chuang hua.*"

"The above plants are grown by the Chinese in their gardens as summer annuals." (*Meyer.*)

23989. PAPAVER SOMNIFERUM L. **Poppy.**

From Peking, Chihli, China. "(No. 1045a, Mar. 25, 1908.) A poppy grown for its ornamental flowers in gardens in North China. Chinese name *Hong yeën swee hua.*" (*Meyer.*)

23990 to 23992. PAPAVER RHOEAS L. **Poppy.**

From Peking, Chihli, China. (Mar. 25, 1908.)

23990. "(No. 1046a.) Chinese name *Hong yii mie ren hua.*"

23991. "(No. 1047a.) Chinese name *Pai yii mie ren hua.*"

23992. "(No. 1048a.) Chinese name *Ten yii mie ren hua.*"

"These flowering poppies are grown by the Chinese as ornamental garden annuals. Sow early." (*Meyer.*)

23993 and 23994. CASSIA OCCIDENTALIS L.

From Peking, Chihli, China. (Mar. 25. 1908.)

23993. "(No. 1049a.) Chinese name *Huang whee tze.*"

23994. "(No. 1050a.) Chinese name *Sing huang whee tze.*"

"The above are grown by the Chinese as ornamental garden plants." (*Meyer.*)

23995 to 23999. POLYGONUM ORIENTALE L. **Prince's-feather.**

From Peking, Chihli, China. (Mar. 25, 1908.)

23995. "(No. 1051a.) Chinese name *Swee ping hua.*"

23996. "(No. 1052a.) Chinese name *Pai mow dan.*"

23997. "(No. 1053a.) Chinese name *Hong mow dan.*"

23998. "(No. 1054a.) Chinese name *Tze mow dan.*"

23999. "(No. 1055a.) Chinese name *Ten mow dan.*"

"All the foregoing varieties of prince's-feather are cultivated by the Chinese of North China in their gardens as ornamental plants. The colors of the bracts range from pure white to dark red. Plants are able to stand alkali very well and may be of use in the Western States." (*Meyer.*)

24000. HIBISCUS sp.

From Peking, Chihli, China. "(No. 1056a, Mar. 25, 1908.) An ornamental plant grown in gardens in North China. Chinese name *Huang tchu kwi hua.*" (*Meyer.*)

24001 and 24002. DATURA sp.

From Peking, Chihli, China. (Mar. 25, 1908.)

24001. "(No. 1057a.) Chinese name *Tze la ba hua.*"

24002. "(No. 1058a.) Chinese name *Ta pai la ba hua.*"

"Both of these are apparently Solanaceæ and are grown by the Chinese of North China as ornamental garden plants. They may prove to be novelties." (*Meyer.*)

23930 to 24113—Continued.

24003 to 24008. Malva sp.

From Peking, Chihli, China. (Mar. 25, 1908.)

24003. "(No. 1059a.) Chinese name *Hong shoo show gee.*"

24004. "(No. 1060a.) Chinese name *Ten shoo show gee.*"

24005. "(No. 1061a.) Chinese name *Pai shi gee hai tang.*"

24006. "(No. 1062a.) Chinese name *Lang shi gee hai tang.*"

24007. "(No. 1063a.) Chinese name *Hong shi gee hai tang.*"

24008. "(No. 1064a.) Chinese name *Pai shi gee hai tang.*"

"The above are grown by the Chinese of North China as ornamental garden plants." (*Meyer.*)

24009 to 24016. Althaea rosea (L.) Cav. **Hollyhock.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24009. "(No. 1065a.) Chinese name *Huang ta show gee.*"

24010. "(No. 1066a.) Chinese name *Lang ta show gee.*"

24011. "(No. 1067a.) Chinese name *He ta show gee.*"

24012. "(No. 1068a.) Chinese name *Sen ta show gee.*"

24013. "(No. 1069a.) Chinese name *Pou ta show gee.*"

24014. "(No. 1070a.) Chinese name *Tze ta show gee.*"

24015. "(No. 1071a.) Chinese name *Hong ta show gee.*"

24016. "(No. 1072a.) Chinese name *Moo ho ta show gee.*"

"The hollyhocks are favorite garden plants with the Chinese of North China, thriving well in the semiarid climate of northeast Asia. Among these preceding numbers there is one said to be black, No. 1067a (S. P. I. No. 24011), but in all probability the seeds will appear to be very much mixed, as with nearly all seeds to be had in China. There may be hardier and more disease-resistant varieties than those we possess at present among this lot." (*Meyer.*)

24017 to 24019. Datura sp.

From Peking, Chihli, China. (Mar. 25, 1908.)

24017. "(No. 1073a.) Chinese name *Hong ba hsien hua.*"

24018. "(No. 1074a.) Chinese name *Pai ba hsien hua.*"

24019. "(No. 1075a.) Chinese name *Lang ba hsien hua.*"

"The above are grown as ornamental plants in North China." (*Meyer.*)

24020 to 24029. Ipomoea purpurea (L.) Roth.

From Peking, Chihli, China. (Mar. 25, 1908.)

24020. "(No. 1076a.) Chinese name *Hong la ba hua.*"

24021. "(No. 1077a.) Chinese name *Huang la ba hua.*"

24022. "(No. 1078a.) Chinese name *Tze la ba hua.*"

24023. "(No. 1079a.) Chinese name *Pai la ba hua.*"

24024. "(No. 1080a.) Chinese name *Sen la ba hua.*"

24025. "(No. 1081a.) Chinese name *Lang la ba hua.*"

24026. "(No. 1082a.) Chinese name *Hua la ba hua.*"

24027. "(No. 1083a.) Chinese name *Luo ching la ba hua.*"

24028. "(No. 1084a.) Chinese name *Noo ho la ba hua.*"

24029. "(No. 1085a.) Chinese name *Shoo hong hua.*"

23930 to 24113—Continued.

24020 to 24029—Continued.

"The above are in all probability different varieties of *Ipomoea purpurea;* grown by the Chinese in North China as ornamental garden climbers against fences and walls. There are said to be all kinds of colors among these, but the seeds are probably very much mixed." (*Meyer.*)

24030. Ipomoea sp.

From Peking, Chihli, China. "(No. 1086a, Mar. 25, 1908.) A species of morning-glory grown in gardens in North China. Chinese name *Lang chu ling tze.*" (*Meyer.*)

24031. Ipomoea sp.

From Peking, Chihli, China. "(No. 1087a, Mar. 25, 1908.) Chinese name *Hu lu pian doh,* which name may be fictitious, as *pian doh* is the name for *Dolichos lablab.* This Ipomoea is grown like the rest of the morning-glories as an ornamental garden vine." (*Meyer.*)

24032. Iris ensata Thunb. (?)

From Peking, Chihli, China. "(No. 1088a, Mar. 25, 1908.) Apparently an Iris, grown as an ornamental plant in gardens in North China. Chinese name *Shir yong chieng.*" (*Meyer.*)

24033 to 24044. Mirabilis jalapa L. **Four-o'clock.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24033. "(No. 1089a.) Chinese name *Luaun hong mu lee.*"

24034. "(No. 1090a.) Chinese name *Luaun huang mu lee.*"

24035. "(No. 1091a.) Chinese name *Luaun pai mu lee.*"

24036. "(No. 1092a.) Chinese name *Luaun sen mu lee.*"

24037. "(No. 1093a.) Chinese name *Luaun tze mu lee.*"

24038. "(No. 1094a.) Chinese name *Luaun hua mu lee.*"

24039. "(No. 1095a.) Chinese name *Huang mu lee hua.*"

24040. "(No. 1096a.) Chinese name *Lang mu lee hua.*"

24041. "(No. 1097a.) Chinese name *Pai mu lee hua.*"

24042. "(No. 1098a.) Chinese name *Sen mu lee hua.*"

24043. "(No. 1099a.) Chinese name *Hong mu lee hua.*"

24044. "(No. 1100a.) Chinese name *Tchung tze hu mu lee hua.*"

"These twelve preceding numbers are varieties of the ordinary four-o'clock, which is a great favorite with the Chinese of North China. They are able to stand considerable alkali in the soil." (*Meyer.*)

24045 to 24058. Impatiens balsamina L. **Balsam.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24045. "(No. 1101a.) Chinese name *Lang ting tung.*"

24046. "(No. 1102a.) Chinese name *Sen ting to tung.*"

24047. "(No. 1103a.) Chinese name *Hong ting to tung.*"

24048. "(No. 1104a.) Chinese name *Tze ting to tung.*"

24049. "(No. 1105a.) Chinese name *Pai ting to tung hua.*"

24050. "(No. 1106a.) Chinese name *Suo ching ting to tung hua.*"

24051. "(No. 1107a.) Chinese name *Hua pien ting to tung hua.*"

24052. "(No. 1108a.) Chinese name *Moo ho ting to tung hua.*"

24053. "(No. 1109a.) Chinese name *Hong lung tsao tung hsien hua.*"

23930 to 24113—Continued.

24045 to 24058—Continued.

24054. "(No. 1110a.) Chinese name *Hua lung tsao tung hsien hua.*"

24055. "(No. 1111a.) Chinese name *Tze lung tsao tung hsien hua.*"

24056. "(No. 1112a.) Chinese name *Lang lung tsao tung hsien hua.*"

24057. "(No. 1113a.) Chinese name *Pai lung tsao tung hsien hua.*"

24058. "(No. 1114a.) Chinese name *Lang hua pien lung tsao tung hsien hua.*"

"All the preceding numbers are apparently varieties of the ordinary balsam, which is much grown by the Chinese as an ornamental summer annual, mostly in boxes and earthen vessels. There are some fine varieties among them, and as a whole they may prove to be somewhat hardier than our own strains." (*Meyer.*)

24059 to 24062. (Undetermined.)

From Peking, Chihli, China. (Mar. 25, 1908.)

24059. "(No. 1115a.) Chinese name *Ta nai kong.*"

24060. "(No. 1116a.) Chinese name *Pai nai kong.*"

24061. "(No. 1117a.) Chinese name *Hong sho yo.*"

24062. "(No. 1118a.) Chinese name *Sun kuan moo.*"

"These four numbers represent apparently a Salvia or some closely allied genus of Menthaceæ; they are grown by the Chinese as ornamental garden plants." (*Meyer.*)

24063 to 24066. DIANTHUS CHINENSIS L. **Chinese pink.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24063. "(No. 1119a.) Chinese name *Hong shir chow.*"

24064. "(No. 1120a.) Chinese name *Ten shir chow.*"

24065. "(No. 1121a.) Chinese name *Tze shir chow.*"

24066. "(No. 1122a.) Chinese name *Pai shir chow.*"

"The above are apparently different varieties of Chinese pinks, which are favorite plants in Chinese gardens." (*Meyer.*)

24067 to 24069. (Undetermined.)

From Peking, Chihli, China. (Mar. 25, 1908.)

24067. "(No. 1123a.) Chinese name *Hong wan sho chii hua.*"

24068. "(No. 1124a.) Chinese name *Pai wan sho chïi hua.*"

24069. "(No. 1125a.) Chinese name *Huang wan sho chii hua.*"

"Grown as an ornamental garden plant in North China." (*Meyer.*)

"These seeds belong to a species of Asteraceæ." (*H. C. Skeels.*)

24070. HELIANTHUS sp.

From Peking, Chihli, China. "(No. 1126a, Mar. 25, 1908.) Apparently a Helianthus or a closely allied composite. Grown as an ornamental garden plant in North China. Chinese name *Hong mi lou sung.*" (*Meyer.*)

24071 to 24073. HELIANTHUS ANNUUS L.

From Peking, Chihli, China. (Mar. 25, 1908.)

24071. "(No. 1127a.) Chinese name *Huang kwi hua.*"

24072. "(No. 1128a.) Chinese name *Cheeoo lien tung.*"

23930 to 24113—Continued.

24071 to 24073—Continued.

24073. "(No. 1129a.) Chinese name *Tsau yang hua.*"

"These sunflower varieties are cultivated in China for their seeds, which are eaten as a delicatesse; for their leaves, which are fed to domestic animals; and for their stalks, which are used for fuel." (*Meyer.*)

24074 and 24075. CRYSANTHEMUM CORONARIUM L.

From Peking, Chihli, China. (Mar. 25, 1908.)

24074. "(No. 1130a.) Chinese name *Hoow tze kang.*"

24075. "(No. 1131a.) Chinese name *Yae liü hsien.*"

"The above are grown by the Chinese in North China as ornamental garden plants." (*Meyer.*)

24076 to 24078. CRASSINA ELEGANS (Jacq.) Kuntze. **Zinnia.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24076. "(No. 1132a.) Chinese name *Hong chung mae hua.*"

24077. "(No. 1133a.) Chinese name *Huang chung ye mae hua.*"

24078. "(No. 1134a.) Chinese name *Pai mu sië mae hua.*"

"The above are apparently varieties of *Crassina elegans*, which is grown sparsely as a garden plant in North China." (*Meyer.*)

24079 to 24081. CALENDULA OFFICINALIS L. **Marigold.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24079. "(No. 1135a.) Chinese name *Ten hsi fan lien.*"

24080. "(No. 1136a.) Chinese name *Hong hsi fan lien.*"

24081. "(No. 1137a.) Chinese name *Chung tsaën tze hua.*"

"The above are varieties of the ordinary marigold, grown as an ornamental garden plant in North China." (*Meyer.*)

24082 to 24085. TAGETES ERECTA L.

From Peking, Chihli, China. (Mar. 25, 1908.)

24082. "(No. 1138a.) Chinese name *Hung chü hua.*"

24083. "(No. 1139a.) Chinese name *Hong chü hua.*"

24084. "(No. 1140a.) Chinese name *Hong fu jung hua.*"

24085. "(No. 1141a.) Chinese name *Huang fu jung hua.*"

"The above are apparently varieties of *Tagetes erecta* or a form closely allied to it. They are grown as ornamental garden annuals by the Chinese of North China." (*Meyer.*)

24086. LACTUCA SATIVA L. (?)

From Peking, Chihli, China. "(No. 1142a, Mar. 25, 1908.) A composite. Grown as an ornamental garden plant in North China. Chinese name *Hong kwei hua.*" (*Meyer.*)

24087 to 24109. CALLISTEMMA CHINENSIS (L.) Skeels. (ASTER CHINENSIS L.) (CALLISTEPHUS CHINENSIS Nees.) **China aster.**

From Peking, Chihli, China. (Mar. 25, 1908.)

24087. "(No. 1143a.) Chinese name *Huang chiang hsi la hua.*"

24088. "(No. 1144a.) Chinese name *Lang chiang hsi la hua.*"

24089. "(No. 1145a.) Chinese name *Hwei chiang hsi la hua.*"

24090. "(No. 1146a.) Chinese name *Hua chiang hsi la hua.*"

23930 to 24113—Continued.

24087 to 24109—Continued.

24091. "(No. 1147a.) Chinese name *Tze chiang hsi la hua.*"

24092. "(No. 1148a.) Chinese name *Nan hong chiang hsi la hua.*"

24093. "(No. 1149a.) Chinese name *Moo ho jung tchü chiang hsi la hua.*"

24094. "(No. 1150a.) Chinese name *Hua yung tchu chiang hsi la.*"

24095. "(No. 1151a.) Chinese name *Fen yung tchu chiang hsi la.*"

24096. "(No. 1152a.) Chinese name *Tze yung tchu chiang hsi la.*"

24097. "(No. 1153a.) Chinese name *Hong yung tchu chiang hsi la.*"

24098. "(No. 1154a.) Chinese name *Pai yung tchu chiang hsi la.*"

24099. "(No. 1155a.) Chinese name *Pai hua pien chiang hsi la.*"

24100. "(No. 1156a.) Chinese name *Tze hua pien chiang hsi la.*"

24101. "(No. 1157a.) Chinese name *Chiang hsi chü.*"

24102. "(No. 1158a.) Chinese name *Pai kwei choo chü.*"

24103. "(No. 1159a.) Chinese name *Hong kwei chow chü.*"

24104. "(No. 1160a.) Chinese name *Huang kwei chow chü.*"

24105. "(No. 1161a.) Chinese name *Lang kwei chow chü.*"

24106. "(No. 1162a.) Chinese name *Fen kwei chow chü.*"

24107. "(No. 1163a.) Chinese name *Tze kwei chow chü.*"

24108. "(No. 1164a.) Chinese name *Hua kwei chow chü.*"

24109. "(No. 1165a.) Chinese name *Moo ho kwei chow chü.*"

"The above are apparently various forms and varieties of our ordinary garden aster, which is held in high esteem by the Chinese as a garden flower. There are said to be yellow-flowered varieties among this collection, but in general the seeds will be found to be very much mixed.

"As the garden aster is a native of northern Asia there may be found some types among this lot that may be of value for breeding purposes or for rather uncongenial climates." (*Meyer.*)

24110 to 24112. PANICUM MILIACEUM L. **Proso millet.**

From northern Korea. (September, 1906.)

24110. "(No. 1168a.) A white-seeded drooping millet."

24111. "(No. 1169a.) A red-seeded drooping millet."

24112. "(No. 1170a.) A black-seeded drooping millet."

"Apparently rare forms of millet grown by the Koreans for food. These few seeds were picked by me, while passing a few fields near the upper regions of the Tumen River and I never came across them again later on." (*Meyer.*)

24113. PANICUM sp.

From northern Korea. "(No. 1171a, September, 1906.) A millet grown on very low lying lands; used by the poor peasants, when ground up, as a gruel. Try it on low river bottoms as a late fodder crop; it stools out enormously on rich land." (*Meyer.*)

24114. ARACHIS HYPOGEA L. **Peanut.**

From Marseille, France. Procured by Hon. Robert P. Skinner, American consul-general, at the request of Mr. W. R. Beattie and Mr. C. S. Scofield. Received October 27, 1908.

Gambia. "Pods medium size to small, light in color, closely netted, indentations quite shallow, so that the exterior surface of pods is comparatively smooth; generally two, sometimes three, and occasionally one pea in a pod; shells thin and quite firm and strong; peas medium size, one-third larger than Spanish, crowded together in pod and almost completely filling cavity, color of pea rather dark brown, outer skin adhering very tightly; flesh of pea clear white color, germ considerably extended at end of pea and easily removed.

"This pea will be exceptionally valuable for use in the manufacture of candy and other products where shelled nuts are required." (*W. R. Beattie.*)

"These peanuts were procured for testing in this country for their oil-yielding properties in comparison with the American varieties." (*R. A. Young.*)

24115 to 24121.

From Amani, German East Africa. Presented by Dr. A. Zimmerman, Biologic Agricultural Institute, at the request of Mr. C. V. Piper. Received October 23, 1908.

"The following seeds of legumes being tested here for their value as green fertilizing plants." (*Zimmerman.*)

24115. CROTALARIA sp.

24116. CROTALARIA sp.

24117. CROTALARIA sp.

24118. CROTALARIA HILDEBRANDTII Vatke.

24119. CROTALARIA STRIATA Schrank.

24120. DOLICHOS (?).

24121. INDIGOFERA (?).

24122 to 24127. ANDROPOGON SORGHUM (L.) Brot. **Kafir.**

From Greytown, Natal, South Africa. Procured from Mr. T. Thresh, "Thornton," Greytown, Natal, by Mr. E. Fitzgerald, Native Affairs Department, Pietermaritzburg, Natal, presented by Mr. A. E. LeRoy, Adams, M. S., Natal. Received October 6, 1908.

Seed of the following. Descriptive notes by Mr. Carleton R. Ball; native names by Mr. LeRoy:

24122. *Mehlo ka kuka. Blackhull* kafir, apparently typical. Small head, 7 inches long; glumes, short, shiny black; seeds medium, white.

24123. *Sibuyana. Blackhull* kafir type; very compact glumes and seeds slightly larger than normal, the seeds are white with distinct brownish tinge, especially at tip.

24124. *Simuktywana. Blackhull* kafir type; head compact, very similar to preceding (S. P. I. No. 24123), but seeds more deeply tinged with brown.

24125. *Ngabani omhlope.* Kafir type of head, but seeds large; whitish or mostly pearly glumes two-thirds as long as seeds, these are greenish or, in the case of those at the base of the head, reddish brown.

24122 to 24127—Continued.

24126. *Ngabani obomvu.* *Red* kafir, apparently typical head, shorter and more slender than normal for the United States.

24127. *U Jiba.* "The natives do not like the taste of this, but raise it because the birds do not trouble it. Birds trouble all other kinds very greatly." (*LeRoy.*)

Related to *Red* kafir, but with very large seeds; glumes about two-thirds as long as seeds.

24128 to 24130. ANDROPOGON SORGHUM (L.) Brot. **Durra.**

From Egypt. Presented by Mr. Hubert S. Smiley, Gallowhill, Paisley, Scotland. Received September 23, 1908.

Seed of the following. Descriptive notes by Mr. Carleton R. Ball; native names by Mr. Smiley:

24128. *Bahr el Bugger.* Typical durra *Ahmar* or brown-seeded durra; glumes shiny black; large seeds, pale and shiny red.

24129. *Hamashi.* "This is considered the best for bread making." (*Smiley.*)

A form apparently intermediate between durra *Ahmar* and durra *Beda* the white form; the seeds are pale brown, head is otherwise identical with durra *Ahmar.*

24130. *Heygeri.* Seeds white or brownish white; glumes shiny black and naked.

"These are typical Egyptian durras with very large and heavy ovate, extremely compact, pendant heads; the same or very similar varieties tested by me in the last few years always have immense stalks, 2 to 3 inches in diameter at the base, 8 to 13 feet high, and having from 20 to more than 30 leaves; they are mostly very late and will therefore not mature in much of our dry plain region; they are not at all adapted to the more humid region, because the compact heads become moldy in wet weather and badly injured by worms." (*Ball.*)

"This durra is sown as a rain crop in Berber, Atbara, Zeidab, and Shendi districts. Directly the rains are over, the natives go out to the borders of the desert and sow the grain on the poor, rocky soil. They then leave it, as it requires no cultivation, and it receives no more water than that left in the soil by the rains. A good crop would be about 6 ardebs per feddan. These sorghums are the principal foodstuffs of the natives." (*Smiley.*)

24131. GARCINIA sp.

From Palawan, Philippine Islands. Procured by Mr. William S. Lyon, Gardens of Nagtajan, Manila, P. I. Received November 4, 1908.

"This species is from sea level, extending from coast inland 3 to 5 kilometers only; is generally 14 to 15 meters, although sometimes larger, wide spreading and seemingly a robust grower. Fruit edible by natives, monkeys, and parrots, but I balked at much of it." (*Lyon.*)

24132. BENZOIN sp. (?)

From Mokanshan, China. Presented by Rev. J. M. W. Farnham, Shanghai, China. Received November 4, 1908.

"This shrub grows 8 or 10 feet tall. In September (here) the branches are covered thick with beautiful, very bright red berries; a bush here and there among the green shrubbery around a lawn would be pretty. Sow in the autumn, I suppose." (*Farnham.*)

24134 and 24135.

From Florida. Grown by Mr. P. J. Wester at the Subtropical Garden, Miami, Fla. Numbered for convenience in recording distribution November 9, 1908.

24134. CHRYSOPHYLLUM MONOPYRENUM Swartz.

"This belongs to the Sapotaceæ and is a native of south Florida, where it grows to a small tree, attaining sometimes a height of about 18 feet. The leaves are leathery and dark green, shining above and satiny beneath, something similar to the star apple, with which many are familiar, only this is darker and more lustrous than that species, making it more ornamental. The fruit is of no value." (*Wester.*)

24135. THESPESIA POPULNEA (L.) Soland.

"This is usually considered a native of the Old World, which has long been naturalized to the West Indies and has probably drifted with the Gulf Stream to the shores of Florida, where it grows wild on the Keys and occasionally on the mainland. This plant will attain a height here of about 20 feet or more and about the same spread under favorable conditions." (*Wester.*)

"These plants will probably be of value in southern California as ornamentals and shade trees. Both stand slight frosts." (*Wester.*)

24136. CRINODENDRON PATAGUA Mol.

From Jamaica Plain, Mass. Presented by the Arnold Arboretum. Received October 26, 1908.

"A tree attaining a height of 30 feet; pyramidal shaped; pretty foliage; very elegant, lily-shaped, drooping, red flowers." (*Dr. F. Franceschi.*)

24137 and 24138. ZEA MAYS L. Corn.

From Ciudad Juarez, Chihuahua, Mexico. Presented by Mr. Elmer Stearns, botanist, School of Agriculture. Received November 2, 1908.

Seed of the following:

24137. "Blue corn, is regular Aztec corn, very much used for tortillas." (*Stearns.*)

24138. "White corn, used same as above (S. P. I. No. 24137)." (*Stearns.*)

24140 to 24145.

Collected near Simla, India, in the Himalayan foothills. Presented by Mr. Evarard Cotes, Greenwood Court, Simla, India, through Mr. Frank N. Meyer. Received November 10, 1908.

Seeds of the following. Descriptive notes by Mr. Frank N. Meyer:

24140. PRUNUS ARMENIACA L. **Wild apricot.**

Resembles the cultivated ones very much.

24141 to 24144. AMYGDALUS PERSICA L. **Peach.**

24141. Probably an improved cultivated form.

24142. Very small pits, probably the genuine wild type.

24143. Small heart-shaped pits.

24144. The pits seem to resemble those of the *Chinese Honey* peach.

24145. PYRUS sp. **Pear.**

A wild variety.

24146. ASPARAGUS FILICINUS GIRALDII C. H. Wright.

From Florence, Italy. Presented by Mr. Pasquale Bauarini, director, Orto Botanico del R. Instituto de Studi Superiori, via Romana 19. Received November 13, 1908.

"The form known in gardens as variety *Giraldii* is characterized by its large, broad, glossy, green phylloclades, usually borne in groups of five, and the solitary green flowers produced on very slender pedicels much longer than the phylloclades. The flower buds are brownish. This form has been collected in China in the Province of Shensi by Père Giraldi and in Szechwan and Hupeh by Dr. Aug. Henry.

"The species is a very variable one, and three varieties of it are enumerated in *Hooker's Flora of British India*, vi. 315, but the variety *Giraldii* has larger phylloclades than either of these." (*Charles Henry Wright, in The Gardeners Chronicle, August 15, 1908.*)

24147. MALPIGHIA GUADALAJARENSIS (Wats.) Rose.

From Ixtlan del Rio, Tepic, Mexico. Presented by Mr. Alfred Lonergan, through Mr. Frederic Chisolm. Received November 12, 1908.

"*Manzanita* or *Manzana del Cerro* (mountain apple). A low-growing tree, with small edible fruits of a taste resembling that of the apple. Grows wild on the steep, rough mountain sides in the eastern part of Tepic Territory and along the contiguous western border of the State of Jalisco, Mexico. The bark is used in tanning, and these fruits were imported to be planted at Brownsville, Tex., and Miami, Fla., to grow trees for this purpose." (*Frederic Chisolm.*)

24148 to 24154. PUNICA GRANATUM L. **Pomegranate.**

From Sidon, Syria. Procured by Mr. G. Bie Ravndal, American consul-general, Beirut, Syria, from Mohamed Effendi Dada, gardener. Received November 13, 1908.

The following cuttings:

24148. *Suneiny.*

24149. *Malissah.*

24150. *Bint el Basha.*

24151. *Zaffani.*

24152. *Mawardi.*

24153. *Mukl el Bagel.*

24154. *Seify.*

"Perhaps the most popular varieties of sweet pomegranates grown here are the *Malissah* (S. P. I. No. 24149) and the *Bint el Basha* (S. P. I. No. 24150). The *Mawardi* (S. P. I. No. 24152) is also rather sweet, but considered slightly inferior to the varieties already mentioned, so also the *Mukl el Bagel* (S. P. I. No. 24153), the latter as well as the *Zaffani* (S. P. I. No. 24151) is somewhat tart, but not as acid as the *Suneiny* (S. P. I. No. 24148). The *Seify* (S. P. I. No. 24154) is well thought of in Syria. It is found in the Damascus region, as well as in the vicinity of Sidon.

"When seeds are planted the trees will be wild and require grafting, while cuttings will produce trees of the variety of the cuttings. Pomegranates out here thrive on shade and water. Rats are very fond of the fruit and climb the trees for meals, leaving the shells of the fruit hanging quite empty." (*Ravndal.*)

24155 to 24165.

From Szechwan Province, China. Secured by Mr. E. H. Wilson, of the Arnold Arboretum, Jamaica Plain, Mass., in cooperation with this Department. Received October and November, 1908.

24155 to 24165—Continued.

The following seeds:

24155. Rubus xanthocarpus Bur. & Franch.

"(No. 806.) Subshrub 6 inches to 1 foot high; flowers white; fruits yellow, of good size and flavor. Common in abandoned cultivated areas and stony places generally in the valley of the Min River from 6,000 to 10,000 feet; abundant around the town of Sungpan. Fruit ripe July to end of August, according to altitude." (*Wilson.*)

24156. Ribes sp.

"(No. 836.) Bush 6 to 12 feet; fruit green and very acid. The common gooseberry, abundantly employed as a hedge plant around Tatienlu; altitude 8,000 to 10,000 feet." (*Wilson.*)

24157. Triticum aestivum L. **Wheat.**

"(No. 845.) A white awnless wheat; 3 to 4 feet high; ripening in May. A common crop on the Yangtze banks, Szechwan Province." (*Wilson.*)

24158. Hordeum vulgare L. **Barley.**

"(No. 846.) Ordinary six-rowed barley; 2 to 3 feet high; ripening in May; cultivated in the Yangtze Valley, Szechwan." (*Wilson.*)

24159. Hordeum sp. **Barley.**

"(No. 847.) A common six-rowed awned barley; ripe in May; abundantly cultivated on the banks of the Yangtze River, Szechwan." (*Wilson.*)

24160. Triticum aestivum L. **Wheat.**

"(No. 848.) A red wheat; 3 to 4 feet high; ripe in May. A common crop in the Yangtze Valley, Szechwan." (*Wilson.*)

24161. Hordeum vulgare L. **Barley.**

"(No. 849.) A barley with purplish glumes, ripe in May; sparingly cultivated in the department of Weichon on the borders of the Chentu plain." (*Wilson.*)

24162. Brassica juncea (L.) Cass. **Chinese rape.**

"(No. 851.) Large Chinese rape, *Ta tsai yu;* 4 to 6 feet high; abundantly cultivated throughout the Yangtze Valley and the Chentu plain." (*Wilson.*)

24163. Brassica sp.

"(No. 852.) Small Chinese rape, *Hsas tsai yu;* 2 to 3 feet high; not quite such a common crop as No. 851 (S. P. I. No. 24162), but very generally cultivated in Szechwan. For special use of these and all the Szechwanese economic plants, see Consul-General Hosie's report on the Province of Szechwan." (*Wilson.*)

24164. Triticum aestivum L. **Wheat.**

"(No. 853.) A red awnless wheat; 3 feet high, with stout culms and ears; cultivated by the tribesfolk in western Szechwan and ripening in July or August, according to altitude. This wheat yields a very fine flour suitable for bread of all sorts." (*Wilson.*)

24165. Fragaria moschata Duchesne.

"(No. 908.) Wild strawberry. Fruit red and of very good flavor, size and shape variable, abundant around Tatienlu, 8,000 to 14,000 feet altitude." (*Wilson.*)

24166 and 24167. MELALEUCA LEUCADENDRON L.

Presented by Dr. John Gifford, Cocoanut Grove, Fla., through Mr. P. J. Wester, in charge, Subtropical Garden, Miami, Fla. Received November 17, 1908.

24166. Seed from Australia.

24167. Cuttings from a tree 18 feet tall growing near Cocoanut Grove, Fla.

"The cajaput-tree of India and Australia. Reaches a height of 80 feet. Can be grown on the edges of salt-water swamps where no Eucalyptus will survive; the tree is believed to be valuable for subduing malarial vapors like Eucalyptus. The lamellar bark is valuable for preserving fruit wrapped in it. The wood is hard, close grained, and almost imperishable underground. The leaves yield as much as 2 per cent of the well-known cajaput-oil, closely allied to that of Eucalyptus." (*Extract from Von Mueller.*)

24168 and 24169. DAHLIA spp. **Dahlia.**

From Boca del Monte, Vera Cruz, Mexico. Presented by Dr. C. A. Purpus, of Zacuapan, Mexico, through Dr. J. N. Rose, associate curator, United States National Museum. Received November 19, 1908.

Seed of the following:

24168. (Rose No. 08.314.) Flower orange or yellow.

24169. (Rose No. 08.315.) Flower purple; 6,000 to 7,000 feet altitude.

24170. MANGIFERA INDICA L. **Mango.**

From Province of Imos, Philippine Islands. Presented by Mr. Donald MacIntyre, Moanalua Gardens, Honolulu, Hawaii. Received November 20, 1908.

Pico. "A variety of merit. It comes true from seed and by that method has been reproduced in that country for generations." (*MacIntyre.*)

24172. ANONA SQUAMOSA L. **Sugar-apple.**

From Antigua, British West Indies. Presented by Mr. A. S. Archer to Mr. P. J. Wester, in charge, Subtropical Garden, Miami, Fla., who forwarded a small quantity to the Department November 9, 1908.

Variety *purpurea.*

24173 to 24192.

From Soochow, Kiangsu, China. Presented by Rev. R. A. Haden, B. D. Received November 14, 1908.

The following seeds. Quoted descriptions by Mr. Haden; descriptions of varieties by Mr. H. T. Nielsen:

24173 to 24175. VICIA FABA L. **Broad bean.**

"These are varieties of the same bean, grown from about latitude 30° to 33°. They are planted in the fall; it is said that planted in the spring they will not produce. Plant 2 to 3 seeds in a hill, space about 1 foot each way. Stalk bushy and about 3 feet to 4 feet 6 inches high; foliage and seed pods quite smooth; blooms light lilac, slightly fragrant; very prolific. Among earliest plants to bloom in spring and these green beans are the earliest to be had in the market. These are cooked in the same way as butter or lima beans; when dry they are also parched and eaten, and, too, they are soaked until tender, the skin peeled off, and cooked, they are very good thus prepared."

24176. SOLANUM MELONGENA L. **Eggplant.**

"A white variety of eggplant, very fine. I send these because I have never seen the white eggplant at home."

24173 to 24192—Continued.

24177 to 24179. PISUM ARVENSE L. **Field pea.**

24177. "Dark green English pea. Planted in fall with rye (October and November here). Stalk 4 to 5 feet high, branching. Flowers small, purple. Considered very prolific."

24178. "Large white English pea. Planted as above (S. P. I. No. 24177); flowers white; stalks larger and more prolific; good."

24179. "Small white. Remarks on the above (S. P. I. No. 24178) will apply to this."

24180 to 24184. GLYCINE HISPIDA (Moench) Maxim. **Soy bean.**

24180. "Plant bunchy."

Looks like *Nuttall*, No. 17253, also like No. 19183.

24181. "Large yellow soy bean, early."

24182. "Green soy bean, early."

Seed looks like *Okute*, No. 19986.

24183. "Small light green variety, early."

Seed similar to *Haberlandt*, Nos. 17263 and 19985, but is a little smaller.

24184. "Large yellow variety, medium early."

Seed looks like *Haberlandt*, No. 17271.

24185 to 24192. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

24185. "*Smallpox* cowpea. This is a variety of what in Louisiana used to be known as the cowpea; however, I never saw any there as fine as these. Rank grower; long vines, tangled and in masses; prolific fruiter."

Markings of seed like *Whippoorwill*, but shape different, having the most pronounced keel of any cowpea I have seen; shape somewhat like *Unknown*.

24186. "Large brown. Ranks in all respects with the above (S. P. I. No. 24185) except that growth is not so rank."

Shape similar to *Unknown*, but keel is longer and sharper and darker colored.

24187. "Small brown. Very prolific; splendid fodder pea."

Looks like an ordinary *Clay*, seed may be a trifle darker and smaller.

24188. "Large black-eyed spotted pea. I have not seen this growing; it was a find and is said to be very good."

Looks something like *Holstein*, but all the black except a few spots is around the hilum.

24189. "*Black*. Rank grower extensively cultivated; weevil very bad in this."

Looks like our ordinary *Black*.

24190. "*Black-Eye* cowpea, large; not as extensively cultivated as other varieties in this collection."

Looks just like our common *Black-Eye*.

24191. "*Black-Eye* cowpea, small; good."

Differs from our common *Black-Eye* only in having smaller seeds.

24192. "*Brown-Eye* cowpea, small; good."

Seed looks like our common *Brown-Eye*, but a little smaller; looks like *Brown-Eye*, No. 17855, from China.

24193. ORYZA SATIVA L. **Rice.**

From Chevy Chase, Md. Grown by Mr. David Fairchild on his place "In the Woods." Received November 23, 1908.

Grown from dry-land rice No. 19188.

"Planted June 5; it matured a crop of ripe grain. I only planted a few kernels and it received no irrigation whatever. One plant had 17 heads on it and though not as tall as irrigated rice it looks like a proimsing thing to me. I also planted the same variety in April and got a good stand, somewhat better than the later planting, i. e., maturing earlier. I surmise that in such seasons as the last one (1908), May would be the best time to sow this rice in Maryland." (*Fairchild.*)

24194. CARISSA CARANDAS L.

From Peradeniya, Ceylon. Presented by Mr. John C. Willis, director, Royal Botanic Gardens. Received November 21, 1908.

See No. 23750 for description.

24195. SCHOENOCAULON OFFICINALE (Schlecht.) Gray. **Cebadilla.**

From Vera Cruz, Mexico. Presented by Mr. William W. Canada, American consul. Received November 10, 1908.

"The party who procured some of this seed for us in 1905 informs us that it is poisonous, containing Veratrum, and is therefore generally used in the form of a tincture for destroying body lice, etc., as also ticks on cattle. There are other varieties of the same species—the *Zygadenus mexicanus* and the *Stenanthium frigidum*, but these are considered as inferior. The plant is indigenous to the soil in some parts of the State of Vera Cruz. Cebadilla is a common commodity procurable of druggists in the United States." (*Extract from letter of Consul Canada, September 18, 1905.*)

24196. CITRUS NOBILIS Lour. (?) **"Naartje."**

From Warm Baths, Transvaal, South Africa. Presented by Mr. C. A. Simmonds, at the request of Mr. R. A. Davis, government horticulturist, Transvaal Department of Agriculture, Pretoria. Received November 30, 1908.

Groenskil. "The word '*Groenskil*' means green skin, and the fruit of this variety bears more resemblance to the Emperor mandarin perhaps than to most others. It hangs for a long time on the trees in good condition, and is the latest ripening variety we have. It is also more hardy than the '*Platskill*' (S. P. I. No. 24326)." (*Extract from letter of Mr. Davis, February 13, 1908.*) See No. 21551 for further remarks.

24197 to 24202.

From Biloxi, Miss. Grown by Prof. S. M. Tracy, special agent, who procured the original seed from Prof. C. F. Baker, Experiment Station, Santiago de las Vegas, Cuba. Received November 30, 1908.

Plants of the following; notes by Professor Tracy:

24197. CALOPOGONIUM COERULEUM (Benth.) Hemsl.

A slender vine, 10 to 15 feet, rooting freely, poor climber, nodules abundant, no flowers.

24198. CALOPOGONIUM ORTHOCARPUM Urb.

A slender vine, 3 to 6 feet, rooting freely, poor climber, nodules abundant, no flowers.

24199. GALACTIA TENUIFLORA (Willd.) W. & A.

A slender, vigorous climber, nodules abundant, no seed.

24197 to 24202—Continued.

24200. Galactia striata (Jacq.) Urb.

A slender, vigorous climber, nodules abundant, no seed.

24201. Teramnus uncinatus (L.) Swartz.

A dense mass of slender vines climbing poorly, nodules fair, no bloom.

24202. Bradburya plumieri (Turp.) Kuntze.

A slender, thrifty climber, nodules few, no bloom.

24203. Cananga odorata (Lam.) Hook. f. & Thoms. **Ilang ilang.**

From Lawang, Java. Presented by Mr. M. Buysman. Received December 11, 1908.

For description and other importations, see No. 22744.

24204. Cucumis sp.

From Ragaa, Bahr el Ghagel, Sudan, Africa. Presented by Mr. Hubert S. Smiley, Gallowhill, Paisley, Scotland. Received September 23, 1908.

"Seed of the *Koreish Battekh* (inedible oil pumpkin) is sown by natives among their other crops, all of which depend on rain. The oil from this pumpkin is used for cooking and other purposes, as is the better known 'semsen' oil. It is also used by the military and other officials, with the addition of tobacco juice, to protect their mules from the bite of the tse-tse fly. The oil is prepared as follows: Seeds are extracted and roasted similarly to the coffee beans; after roasting the seeds are ground up on a stove; after grinding they are thrown into a pot with oil and boiled. The oil comes to the top and is skimmed off for use." (*Smiley.*)

24205. Vicia leavenworthii Torr. & Gray.

From Arizona. Presented by Mr. Vernon Bailey, Bureau of Biological Survey, United States Department of Agriculture. Received December 3, 1908.

"These vetch seeds were collected September 23, 1908, at 8,500 feet altitude in the White Mountains of Arizona. The plant is abundant throughout Transition Zone, or from about 7,500 to 9,000 feet in the open yellow pine forest. It grows as a spreading bush 2 feet high and in many places covers the ground as an almost solid field of peas, loaded with fruit.

"Our horses were very fond of it and ate both pods and plant eagerly. For a week they had no other grain and ate little else, but steadily gained in flesh.

"Wild turkeys and grouse also feed on both its pods and leaves. It seems to be an unusually valuable forage plant." (*Bailey.*)

24206 to 24310.

From Chile. Received through Mr. José D. Husbands, Limávida, Chile, December 4, 1908.

The following seeds and plants; notes by Mr. Husbands:

24206 and 24207. Greigia sphacelata (R. & P.) Regel.

24206. "Very spiny." (*R. A. Young.*)

24207. "Slightly spiny." (*R. A. Young.*)

24208. Persea lingue (R. & P.) Nees.

This is a very valuable industrial forest tree of large size, handsome, compact, evergreen, has glossy gray-blue-green leaves and is an extra quick grower; here it is not a delicate plant but grows quickly in any soil that is wet or very moist, also in water. The wood is light and tough like elm, but takes a very

24206 to 24310—Continued.

24208—Continued.

high finish. Its lumber is highly esteemed and is lasting if protected from the wet; used for furniture, bodies and poles of carts, ox yokes, etc. The wood is the color of white ash, finished has a yellowish tinge, takes any stain. Its bark is solely used for tanning and is largely exported to Europe. Every station south is filled to overflowing with thousands of bags of broken bark awaiting transportation. The forests are being stripped; in a very few years this tree will be very scarce. It is an extra beautiful shade tree. Its leaves are poisonous to animals, especially sheep, who are very fond of them. Medicinally it is a powerful astringent.

24209. JUGLANS NIGRA L. **Black walnut.**

The *Bolivian* black walnut is of Bolivian origin and is a notable, majestic forest tree with handsome hanging foliage; a quick grower of great industrial value. Its wood is exploited largely in Bolivia, is a hardwood beautifully veined in dark and light grains, taking a very high finish and useful for any purpose. I have seen treelets 8 months old that measured 1 inch in diameter 3 feet from the ground, and 8 feet high. The fruit is large, abundant, and oily, but is not edible on account of its bitterness. These trees have been recently introduced into Chile and few are bearing any considerable quantity of fruit.

24210. MEDICAGO SATIVA L. **Alfalfa.**

From Huasco in the northern part of Chile. It is called by botanists *Medicago sativa*, notwithstanding it is a new and very valuable strain still unnamed. In past times both common central Chile alfalfa and "Alfalfa Peruano" were sown; this I believe to be a cross between the two which combines the merits of both and is said to be the most valuable seed known.

24211 to 24225. Stringless beans grown by irrigation:

24211 and 24212. PHASEOLUS VULGARIS L. **Bean.**

24211. Fair quality only; prolific.

24212. Very good class having large, good-flavored pods; productive.

24213. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

A curious bean, has pods from 12 to 18 inches long; "Monkey's tail."

24214 to 24225. PHASEOLUS VULGARIS L. **Bean.**

24214. "*Alqueado.*" Very good and extra productive.

24215. Cream-colored pods, good flavor, productive.

24216. Extra superfine class, extra fine flavor, early, very prolific; a splendid bean to be eaten green.

24217. Green-colored pods, very prolific, medium quality.

24218. Early, good.

24219. "*Cholos.*" Extra good class; extra large pods of good flavor; prolific.

24220. Early, good.

24221. Very good class.

24222. Cream-colored pod, extra early.

24223. Very good and extra productive.

24224. "*Turruco.*" Good, prolific.

24225. Good class. Thin pod, good flavor, very prolific.

24206 to 24310—Continued.

24226 to 24228. Phaseolus coccineus L. **Scarlet runner bean.**

Beans of the Lima class used both for food and their flowers:

24226. "*Pallares.*" Extra good.

24227. Flowers bright crimson.

24228. Flowers pink and scarlet.

24229 to 24261. Phaseolus vulgaris L. **Bean.**

24229 to 24231. Field beans grown dry in the poorest soil:

24229. Grown dry but in better and more moist soil than the other samples (S. P. I. Nos. 24230 and 24231).

24230. Grown on the coast. Yellow; prolific.

24231. "*Chinalya.*" Grown on the coast.

24232 to 24261. Field beans. Names are unreliable; the same beans are known by different names in different sections; should there be duplicates, they are grown under such distinct conditions as to water, soil, etc., as to justify sending them:

24232. Unknown.

24233. Productive and extra fine.

24234. Unknown.

24235. Unknown.

24236. "*Trigo*" (wheat). Irrigated, extra fine, standard class.

24237. "*Porotos Blanco*" (white beans). Excellent class; irrigated.

24238. "*Baya Grande.*" Productive, largely sown, extra good.

24239. "*Baya Grande Pintado.*" A very good and profitable bean; irrigated.

24240. No data. I think it would grow dry.

24241. No name. Irrigated; extra fine table class like *Mendes;* there are two sorts in this lot.

24242. A white class very similar to others sent. These are grown at a distance in distinct soil and conditions. Extra good.

24243. "*Mendes Blanco.*" A first-class table bean; irrigated.

24244. Irrigated; grown in sticky black clay, extra fine table class.

24245. "*Manteca Claro*" (light-colored lard). An extra fine class of standard table beans.

24246. "*Coscorrones.*" Extra superfine class, very productive in good soil; irrigated.

24247. "*Bayas Oscura*" (dark bay). Largely sown for the working class.

24248. A valuable bean in every sense.

24249. "*Gentlemen.*" A standard class, extra good; irrigated.

24250. "*Burritos*" (little donkey). Extra good; I think the same as "*Burros Claro*" (S. P. I. No. 24260).

24251. Irrigated; extra fine table variety.

24252. "*Aparecido.*" Largest sown and best bean in Chile for laborers. Irrigated.

24206 to 24310—Continued.

24229 to 24261—Continued.

24232 to 24261—Continued.

24253. "*Rosillo.*" Productive and very good. Irrigated.

24254. A splendid variety for rich and poor. Swell to good size.

24255. Extra early; yellow pods; noncreeper; productive and extra good.

24256. "*Mendes.*" Irrigated. A fine table variety, extra good.

24257. "*Baya Chicha.*" Largely sown, profitable and good.

24258. "*Amarilla*" (yellow). Extra fine and very productive; a good bean.

24259. "*Aparecido Pintado.*" The largest sown and one of the best beans for the laboring classes.

24260. "*Burros Claro.*" A first-class bean, white when cooked. Irrigated. I think these are the same as "*Burritos*" (S. P. I. No. 24250).

24261. "*White Coscorrones.*" Extra superfine variety, productive in good soil. Irrigated.

24262. Pisum arvense L. **Field pea.**

Exquisite flavor, sweet, medium late, prolific; white flower; extra fine variety.

24263. Cynara scolymus L. **Artichoke.**

"*Chileno.*" Common sort.

24264. Vicia faba L. **Broad bean.**

Very large and early.

24265. Cicer arietinum L. **Chick-pea.**

"*Garbanzas.*" Grown dry in poor soil. Sown the same as beans in rows or hills.

24266. Lupinus sp.

A papilionaceous legume which grows wild in the sands near the seacoast. Yellow flower. Might be made a food plant.

24267. Lupinus sp.

A papilionaceous legume which grows wild in the sands near the sea. Blue flower. Said to be used roasted as a substitute for coffee, but I think it is bad for this purpose. Might be made a food plant.

24268 to 24278. Cucurbita sp. **Squash.**

24268. Mottled skin, black and red variety; large size; very good.

24269. Mottled skin, yellow and dark green; large size; very good.

24270. Extra good variety; thick, mealy, sweet flesh; large and prolific.

24271. Extra good class, medium size; prolific; meat very thick, mealy, and extra sweet.

24272. Light drab color; large size and prolific; medium quality.

24273. Oblong shape.

24274. Yellow and drab color; medium thick and sweet flesh.

24275. Flesh color and white; thick meat.

24276. Blackish green with white stripes; thick, mealy, sweet flesh; prolific; extra good.

24206 to 24310—Continued.

24268 to 24278—Continued.

24277. Thick, sweet flesh; productive; extra good.

24278. White skin; thick, mealy, sweet meat; good.

24279 and 24280. CUCURBITA PEPO L. **Pumpkin.**

24279. A distinct class of good quality, about 20 inches long and from 4 to 6 inches wide; prolific and a good keeper.

24280. A distinct class; sweet but fibrous; grows large.

24281 to 24293. CUCURBITA sp. **Squash.**

24281. A black-skinned variety having thick, mealy, sweet flesh; good.

24282. Sweet, mealy, fiberless, and fleshy; good.

24283. Greenish white tint; thick, mealy, sugar-sweet flesh, no fiber; extra good.

24284 and 24285. (No description.)

24286. Extra good class; medium size; thick, mealy, fiberless, extra sweet flesh; prolific.

24287. Black skin, fine sort.

24288 to 24291. (No description.)

24292. A very good variety, called here tin colored; sweet, thick, fiberless flesh; large size; prolific; good keeper.

24293. (No description.)

24294 to 24301. CAPSICUM ANNUUM L. **Pepper.**

Aji Chielno. Various sorts in daily use; noted for their extra fine flavor. Chile gave potatoes and red peppers to the world.

Ground or pounded with stones and mixed with finely chopped onions washed in salt and water and afterwards squeezed dry and wet with vinegar, they form a delicious seasoning sauce. In cooking it is used as "color." Heat the fat or butter until it is hot enough to sputter when a drop of water is dropped into the same, put the pounded or coarsely ground peppers into the same, and leave about a quarter of a minute; then add a little cold water, the object being to extract the color and flavor of the peppers in the grease and not permit the fire to so cook the peppers as to spoil the color or make the fat bitter or of bad flavor from overcooking. This red grease is used in every kitchen to flavor all unsweetened foods. The degree of hotness is determined by the amount of grease employed. Anything fried or roasted is much improved by its use; meats, fowls, and vegetables (especially onions) fried first in "color" and afterwards made into soups, etc., are fine in flavor and attractive in appearance.

24294. Small size, hot kind.

24295. Common variety in daily use in every house.

24296. Common variety in general daily use.

24297. Pepper eaten green in soups, sauces, etc.

24298. Common hot sort.

24299. Medium hot, common variety.

24300. "*White Chileno.*" Eaten green as a relish in soups, sauces, salads, pickles, etc., not nearly as hot as tabasco but better flavor.

24301. "*Goat Horns.*" Common variety in daily use.

24302. SOLANUM sp.

24206 to 24310—Continued.

24303 and 24304. Opuntia ficus-indica (L.) Mill.

24303. Fruit of this is oblong and ripens in winter; the leaf is narrow and 2 to 3 feet long.

24304. Fruit of this ripens in midsummer; the leaves are large and thick; the thorns are very small.

24305. Andropogon sorghum (L.) Brot. **Durra.**

A food plant recently found in Chile; unknown.

"White durra with small, semicompact heads; glumes very pale and densely hairy, due probably to dry environment; seeds small, circular, and less flattened than in our domestic variety; florets awned; resembles somewhat the white durra of Syria." (*Carleton R. Ball.*)

24306. Cucurbita sp.

Alcayota, vegetable marrow; used for making preserves.

24307. Cannabis sativa L. **Hemp.**

The ordinary Chile sort; about the year 1545 it was introduced by the Spanish and has been largely grown since.

24308. Hordeum vulgare L. **Barley.**

The common Chile sort; grown on dry hills in the worst class of red clay soil; if this same seed is sown in better land it increases largely in weight and size and grows cleaner. This seed is sent as harvested and thrashed by mares.

24309. Acacia cavenia (Mol.) Bert.

"*Espino de Chile.*" An exceedingly valuable wild thorn tree, grows abundantly throughout central Chile, seeks the driest regions, and is generally used for fences, is impassable and durable if cut when the sap is down; when green, is flexible. It is used as a fence without posts, but more generally is woven between three wires, thus making a very cheap and effective fence. The wood is red streaked with black, extra hard, is used for cogs in mill wheels, and spokes of the heaviest carts, coaches, etc., are made from it. This wood makes the best, hottest, and most lasting charcoal, used exclusively for heating dwellings. Grows quickly in worst dry soil of any class; the long taproot reaches moisture at great depths in a few months. Sheep and goats are especially fond of the new leaf growth and the seeds. The seeds are sown with the dung of these animals. They require a long soak. These trees, when cut, quickly sprout anew. Their natural shape is half round; when pruned, they grow round. It is a splendid shade tree. Leaves are very fine and beautiful. Every part of the branches blooms (the females only) early upon the naked tree before leafing, forming a dense mass of yellow flowers so deliciously fragrant that the fragrance is extracted by the Paris perfumers.

24310. Cryptocarya rubra (Mol.) Skeels.

Peumo with crimson fruit.

24311. Citrus aurantium sinensis L. **Sweet orange.**

From Brazil. Presented by Mr. Pierre Paul Demers, American consul, Bahia, Brazil. Received December 11, 1908.

Bahia navel orange. "These scions were cut from very healthy orange trees, namely, the navel orange grafted upon the 'Laranja da terra.' I have eaten an orange from one of these trees measuring 15 inches in circumference, and its flavor was delicious. About one-third of these scions came from that particular tree.

24311—Continued.

"According to planters here the scions grafted upon 'Laranja da terra' give better results than those grafted upon the 'Laranja tanga.' For that reason the latter is not much used.

"These scions come from practically the only regular orange grove in this city, located at Cabula, about 3 miles from this place. The soil upon which the trees grew contains 60 per cent, more or less, of reddish clay. Navel oranges retail here for 3 and 4 cents each. They are not raised in sufficient quantities to supply the local demands, a fact which is only attributable to the laziness of the natives." (*Demers.*)

24312. VITIS VINIFERA L. **Grape.**

From Beni Abbes, Africa. Presented by Dr. L. Trabut, Mustapha, Algiers, Algeria. Received December 11, 1908.

"Large late grape. Reproduces itself from seed." (*Trabut.*)

24313. ILEX PARAGUARIENSIS St. Hil.

From Buenos Aires, Argentina. Presented by Hon. Carlos Thays, director, Government Botanical Gardens. Received December 12, 1908.

For description, see No. 3035. For previous introductions, see that number; also, Nos. 8953 and 19105.

24314 to 24325.

From De los Villares de la Reina, Salamanca, Spain. Procured by Mr. M. Fraile, of this Department, at the request of Mr. Walter T. Swingle. Received September 15, 1908.

The following seeds, descriptive notes by Mr. Fraile:

24314. PISUM SATIVUM L. **Pea.**

The common narrow-podded garden pea of Spain.

24315. VICIA MONANTHOS (L.) Desf.

This is used for making a food concentrate for animals, being ground and mixed with coarser material, such as straw and the like.

24316. LATHYRUS SATIVUS L. **Grass-pea.**

"*Muelas.*" Used both as a food and for feeding animals.

24317. AVENA SATIVA L. **Oat.**

Common variety of oats in the vicinity from which this particular sample came, near the village of De los Villares de la Reina, in the Province of Salamanca.

24318. HORDEUM VULGARE L. **Barley.**

In this particular vicinity this variety is used for feeding and not for brewing.

24319. VICIA ERVILIA (L.) Willd. **Bitter vetch.**

An unknown variety. This vetch is ground like the algarroba (S. P. I. No. 24315) and mixed with roughage as a feed for oxen.

24320. LENS ESCULENTA Moench. **Lentil.**

Used as a food and for fattening pigs.

24321. CICER ARIETINUM L. **Chick-pea.**

One of the commonest articles of food among a large proportion of the population of Spain.

24322. CICER ARIETINUM L. **Chick-pea.**

This variety is prized for its greater endurance of untoward conditions than the preceding (S. P. I. No. 24321) and giving higher yields.

24314 to 24325—Continued.

24323. TRITICUM AESTIVUM L. **Wheat.**

Candeal (white or summer). A common variety of bearded wheat used for bread making in Spain.

24324. TRITICUM DURUM Desf. **Durum wheat.**

Rubion (red). A hard, bearded wheat, said to be used to some extent in the making of macaroni and for fattening pigs.

24325. TRITICUM AESTIVUM L. **Wheat.**

Mocho. A beardless variety of wheat grown in Spain.

24326. CITRUS NOBILIS Lour. (?) **"Naartje."**

From Warm Baths, Transvaal, South Africa. Presented by Mr. C. A. Simmonds, at the request of Mr. R. A. Davis, government horticulturist, Transvaal Department of Agriculture, Pretoria. Received December 14, 1908.

Platskill. "The meaning of *Platskill* is flat or smooth skin and appears also to apply to the shape of the fruit. The skin of this variety adheres closely to the segments and there is never any of the puffiness which accompanies so many varieties of mandarins. Although so closely adhering, it can be easily removed with the thumb and finger, but it is not exactly what one would call a 'kid glove' orange." (*Extract from letter of Mr. Davis, dated February 13, 1908.*) See No. 21551 for further remarks.

24327 to 24332. ORYZA SATIVA L. **Rice.**

From Honolulu, Hawaii. Received from Mr. F. G. Krauss, in charge of Rice Investigations, Hawaii Experiment Station, December 14, 1908.

Seed of each of the following rices, descriptive notes by Mr. Krauss:

24327. Sample of our old type Japan seed, No. 153, which has been carefully selected for some years.

24328. Variety No. 144, originally received through your Bureau as S. P. I. No. 12765. A very dwarf type of Japan seed; plant averaging less than 20 inches in height, fine foliaged and stemmed, of spreading habit, heavy tillering, 25 fruiting culms per plant; small seeded; matures in one hundred to one hundred and ten days from sowing.

24329. Variety No. 161 (*Omachi*), 24 inches to 28 inches tall; slightly spreading and inclined to lodge in heavy weather. Yields well and produces a good kernel; one hundred and ten to one hundred and twenty days to maturity. Similar to No. 153 (S. P. I. No. 24327).

24330. Variety No. 162 (*Shimokaburi*), 26 inches to 30 inches tall; of erect growth; tillers well and bears heavily; kernel not of highest type.

24331. Variety No. 165. An opaque kernel type; 36 inches to 40 inches tall; inclined to lodge; yields well; a kernel suited to the manufacture of oriental cake flours; matures one hundred and twenty days.

24332. Variety No. 163. Japan type, received by Hawaii station from Dr. G. Otsaka, Imperial Agricultural Experiment Station, Kumamoto, Japan, fall of 1907. Said to be "the most prevailing variety in the southern prefectures," there called "Shinriki" or "Sinriki."

Seed sown February 12, 1908; matured and was harvested June 25. Height 25 inches to 28 inches; fine stemmed; well foliaged; tillers well; quite spreading, but not inclined to lodge. Yields prolifically a medium small kernel of excellent quality. Recommended for further trial.

24333. Tumion californicum (Torr.) Greene.

California nutmeg.

From San Francisco, Cal. Presented by Mr. Marsden Manson, Mechanics Bank Building. Received November 21, 1908.

'This is a rare and very beautiful ornamental tree, reaching a size of at least 3 to 4 feet in diameter and 50 to 75 feet in height, with handsome dark olive-green leaves, somewhat like the leaves of the large fir. It requires a deep, moist, and well-drained loam, and is a fairly rapid grower after once starting. The nuts sprout quickest if planted in a paper or straw box and carefully hulled." (*Manson.*)

24334. Ceratonia siliqua L. **Carob tree.**

From Miami, Fla. Received from Mr. P. J. Wester, in charge, Subtropical Garden. Received December 14, 1908.

Grown from No. 6342. See No. 3112 for description.

24335 and 24336.

From Marandellas, Rhodesia, South Africa. Presented by Mr. J. H. Finch through Mr. W. D. Warne, Umtali, Rhodesia. Received December 14, 1908.

The following seeds:

24335. Eleusine coracana (L.) Gaertn. **Ragi millet.**

24336. Pennisetum americanum (L.) Schum. **Pearl millet.**

24337. Thespesia populnea (L.) Soland.

From Miami, Fla. Received from Mr. P. J. Wester, in charge, Subtropical Garden, December 16, 1908.

See No. 24135 for description.

24338. Pinus peuce Griseb.

From Bulgaria. Presented by Prof. C. S. Sargent, Arnold Arboretum, Jamaica Plain, Mass. Received December 17, 1908.

"This is one of the best exotic pines for the Northern States." (*Sargent.*)

24339 to 24347.

From Pretoria, Transvaal, South Africa. Presented by Prof. J. Burtt Davy, agrostologist and botanist, Transvaal Department of Agriculture. Received December 15, 1908.

The following seeds:

24339. Andropogon sorghum (L.) Brot.

"Variety *Roxburghii.* The dark glumes are gaping and involute at maturity; seeds much as the following (S. P. I. No. 24340) but more flinty; awned." (*Carleton R. Ball.*)

24340. Andropogon sorghum (L.) Brot.

"Probably variety *Roxburghii.* Seeds medium size, somewhat flattened, flinty." (*Carleton R. Ball.*)

24341. Vigna unguiculata (L.) Walp. **Cowpea.**

24342. Pisum arvense L. **Field pea.**

24343. Eleusine coracana (L.) Gaertn. **Ragi millet.**

24344. Sesamum orientale L. **Sesame.**

24345. Arachis hypogaea L. **Peanut.**

24346. Phaseolus vulgaris L. **Bean.**

24347. Oryza sativa L. **Rice.**

24348. DIOSCOREA sp. **Yam.**

From Manila, Philippine Islands. Presented by Mr. W. S. Lyon. Received December 16, 1908.

"*Tongó.* This is far the best yam in existence, in my opinion, which is based upon experience with two or three of the alleged best varieties of both the East and West Indies.

"Habitat: Thin wooded or brush lands, growing in pretty stiff clay. Ripens and stays dormant in the ground from October or November until the following May." (*Lyon.*)

24349. HIPPEASTRUM sp.

From Caldera, Chile. Presented by Señor Enrique E. Gigoux. Received December 18, 1908.

"A yellow-flowered ornamental form." (*P. L. Ricker.*)

24350. BAMBOS SENANENSIS Franch. & Sav. **Bamboo.**

From Japan. Purchased from the Yokohama Nursery Company, Yokohama, Japan, through Mr. William D. Hills, agricultural explorer. Received November 27, 1908.

"Seed produced in Shinshu and Hida provinces only." (*Hills.*)

Suzu-Dake. "This bamboo also goes by the following names: *Yama-Dake*, *Mi-Suzu*, and *No-Suzu*, and in several of the provinces is often called *Hei-Jiku-Chiku*. It resembles *Kuma-Zasa* (*B. veitchii* or *B. palmata*, both of which go by this name) but is larger. The nodes are not prominent and the largest stems attain a growth of 1 sun (inch) with a stature of 10 feet and more. The leaves are 5 or 6 sun in length with a width of about 1 sun, narrower than those of the sasa and tapering off at the tip. Seen from a distance the tree resembles *Miscanthus sinensis* (*Xiphagrostis japonica* (Thunb.) Coville).

"*B. senanensis* grows wild on mountains and open uplands and resists the greatest extremes of cold. It spreads right into the deepest recesses and up to the highest summits of the mountains. In some places it grows and spreads over an extent of many square miles, being especially abundant at Suwa and Kiso, in the province of Shinano, and the hills of Nambu in the province of Rikuchiu.

"In China this bamboo is said to be used for making arrows. It is tough and flexible, so that crooked stems can be easily straightened, but the slender culms of those found in the Kiso Mountains are perfectly straight and well formed. They are split in half and plaited into baskets of various shapes and into mats, forming one of the products of Shinano. Where this bamboo grows wild it hinders the development of trees and obstructs the path of the mountaineer; but it is very useful for binding together the crumbling sides of declivities and for thatching the cottages of the peasantry, in mountainous parts of the country.

"Both in China and in the northern parts of Japan the young sprouts are pickled and eaten. Furthermore, the seeds of this plant and of the sasa furnish the poorer classes with food.

"In 1843 all the bamboos around the town of Takayama, in Hida, for a distance of many miles seeded, and the population, young and old, assembled to harvest the crop at the rate of 5 or 6 *to* (equals one-half bushel) per diem—in all, some 250,000 *koku*. (the koku equals 5 bushels, nearly). This bamboo seed resembles wheat somewhat, both in shape and taste, the common people calling it natural rice or bamboo corn. It is eaten either parched or ground, the flour being made into small dumplings and coarse vermicelli. Chemical analyses show that the composition is the same as that of wheat or rye." (*Adapted from Satow's Cultivation of Bamboos in Japan.*) (*Walter Fischer.*)

24350—Continued.

"Introduced especially for the purpose of testing its stems in the manufacture of a matting woven for the purpose of taking the place of ordinary laths. If the stems are suitable for lath-matting purposes it may be possible to grow this bamboo profitably on steep hillsides in the South. Its use as a soil-binder is worthy of consideration, but the effect on the development of trees should be carefully considered before the plant is given a wide distribution." (*David Fairchild.*)

24351. ALEURITES MOLUCCANA (L.) Willd. **Candle nut.**

From Honolulu, Hawaii. Received through Mr. J. E. Higgins, horticulturist, Agricultural Experiment Station, December 17, 1908.

"Seeds procured for experiments in Cuba, Isle of Pines, and Porto Rico and for the expression of samples of candle-nut oil for analysis and comparison with the oils furnished by other species of the same genus.

"*Aleurites moluccana* (very generally known also under the synonym of *A. triloba*) is at home throughout Malaysia and Polynesia and has been naturalized on the tropical mainland of Asia, in Madagascar, and other tropical countries. It is abundant in the forests of New Guinea, Queensland, Samoa, Tahiti, New Caledonia, Fiji, and many of the Malayan Islands, extending to the Philippines. It is strictly an East Indian or Polynesian plant and may not originally have been native farther west than Java. The tree in its native haunts appears to prefer protected situations, being common in woods and especially in narrow valleys and gullies. It grows luxuriantly to an altitude of 3,000 feet, becoming gradually rarer to 4,000 feet, when it falls off altogether. It is a rapid grower and gross feeder, and propagates itself readily from seeds, which sprout in from 4 to 5 weeks. Its large, three-lobed leaves, silvery pubescent underneath and glossy above, make it admirably suited for shade and ornament in tropical countries, where it should be planted for its valuable seeds.

"The fruits resemble in size, and somewhat in appearance, the black walnut, with a thick fleshy rind and one or two heart-shaped seeds about the size of a horse-chestnut. The seeds or nuts are very thick shelled, containing but 33 per cent of kernel. The kernels yield approximately 60 per cent oil, making for the unshelled seeds 20 per cent of oil, which, owing to the thickness of the shells, is lower than that for *Aleurites fordii*, although the percentage of oil in the kernel is higher than in the Chinese species. The raw kernels are purgative, but are said to lose this property when roasted; so, too, the half-ripe seeds are considered of delicate flavor when eaten with salt, while the ripe ones are unwholesome. The Pacific islanders roast or cook the nuts slightly, when the shells can be broken with a light tap. The kernels are then threaded on bamboo splinters or cocoanut-leaf ribs, bound in leaves or bark, and in this way beautifully bright burning, but sooty and disagreeably smelling torches are obtained—herein the origin of the name candle nut.

"Candle-nut oil is known and sold under many names, which are used also to designate the tree or nuts which produce it: In Hawaii, kukui; in Ceylon, kekune; in India, belgaum walnut; in Jamaica, Spanish or country walnut; in the Philippines, lumbang; in French colonies, bancoul or noix de Moluques or chandelles (candle). According to Louis Edgar Andés the oil compares favorably with linseed in the durability of products made from it, but with some advantage over the latter in the rapidity with which it dries. It can consequently be used industrially for the manufacture of the same products. Its present price however—due principally, it seems, to the lack of cheap and efficient methods of shelling the nuts—does not allow it to compete with linseed. Candle-nut oil is not imported into the United States, but small quantities of the kernels find their way from Australia, various parts of Polynesia and Malaysia and the Philippines to European ports, where the oil expressed from them is used principally for soap making." (*Walter Fischer.*)

24353 to 24364.

From Chile. Received through Mr. José D. Husbands, Limávida, Chile, December 17, 1908.

The following seeds, with notes by Mr. Husbands:

24353. Medicago sativa L. **Alfalfa.**

Imported from Switzerland.

24354 to 24357. Cucurbita sp. **Squash.**

24354. Extra large; good for fodder.

24355. From Curico. A good table class.

24356. From Curico. A good table class.

24357. From Rancagua. A good table class.

24358. Solanum tuberosum L. **Potato.**

"*Perhuenchas.*" Named from an Indian tribe of the same name. Grown without deterioration from the beginning of colonial days.

24359. Passiflora quadrangularis L.

"*Pasionaria de Ecuador.*" Has an edible fruit; I think it has a blue flower. Grown in Chile.

24360. Passiflora pinnatistipula Cav.

"*Pasionaria de Chile.*" The wild residence of this plant is in the provinces of Valparaiso and Aconcagua, near the sea. It belongs to the subgenus *Tacsonia* of *Passiflora*.

24361 to 24364. Anona cherimola Mill.

24361 and 24362. (No remarks.)

24363. Somewhat small, with dark skin.

24364. A large variety, about 5 inches by 4 inches; a splendid fruit.

24365 and 24366. Malus spp.

From Jamaica Plain, Mass. Presented by Mr. Jackson Dawson, Arnold Arboretum. Received December 19, 1908.

Seeds of the following:

24365. Malus sylvestris × baccata.

24366. Malus baccata (L.) Moench.

"These are extraordinary keepers, and, as most of our crab apples are not good keepers, these therefore may be used in experimental work." (*Dawson.*)

To be used in breeding or as stocks in cooperative experiments with the Mississippi Valley Apple Breeders' Association.

24367. Medicago sativa L. **Alfalfa.**

From Arabia. Purchased from Mr. H. P. Chalk, manager for the Hills Brothers Company, in Bussorah, Persian Gulf, through Mr. William C. Magelssen, American consul, Bagdad, Turkey. Received December 5, 1908.

Arabian alfalfa or *Jet.* (See No. 12992 for description.) This has proved of great promise in Arizona and California.

24368. Panicum sulcatum Aubl.

From Miami, Fla. Received through Mr. P. J. Wester, in charge, Subtropical Garden, December 5, 1908.

24368—Continued.

"This plant does exceedingly well here, and it has recently occurred to me that it would be a successful and cheap substitute for palms for decorative purposes in the North." (*Wester.*)

"This is extensively grown in gardens in Mexico as an ornamental under the name of 'Hoja de vandera.'" (*Frederic Chisolm.*)

24369. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

From Biloxi, Miss. Procured by Prof. S. M. Tracy. Received November 25, 1908.

"A variety of cowpea, the vines of which were 50 feet long, and it was stated by the owner to grow 100 feet long. The plants were dead when I saw them, but the owner states that the plant is perennial. The pods are very large, measuring 10 inches in length and ½ inch in width, while the seeds closely resemble those of the ordinary *Whippoorwill* variety." (*Tracy.*)

24370 to 24401.

From Russia. Received through Prof. N. E. Hansen, director, Agricultural Experiment Station, Brookings, S. Dak., December, 1908, while traveling as an agricultural explorer for this Department.

The following seeds and cuttings:

24370. RIBES NIGRUM L.

24371. RIBES sp.

"(No. 5.) A wild black currant from near village Mali Ssusum, steamer landing place on the Obi River, a short distance north of Barnaul, Tomsk, western Siberia." (*Hansen.*)

24372. RIBES sp.

(Stat. Baljatakaija.)

24373. RIBES sp.

24374. RIBES sp.

"(No. 96.) A wild black currant from Taischet, between Krasnojarsk, central Siberia, and Irkutsk, on Lake Baikal, Siberian railway. For fruit breeding." (*Hansen.*)

24375. RUBUS sp.

"(No. 1.) A red wild raspberry as found native at Besentsug, near Samara, Volga River region, Russia. For fruit breeding." (*Hansen.*)

24376. RUBUS FRUTICOSUS L.

"(No. 6.) A wild raspberry gathered near Gorodische, on Obi River, a few miles north of Barnaul, Tomsk, western Siberia. Fruit much gathered by peasants and sold at steamer landings." (*Hansen.*)

24377. RUBUS FRUTICOSUS L.

"(Nos. 30 and 31.) A wild raspberry much gathered by peasants in western Siberia; this was procured at steamer landing Katschiskaya. For fruit breeding." (*Hansen.*)

24378. RUBUS sp.

"(No. 34.) Wild red raspberry from station Tiaschet, between Krasnojarsk, central Siberia, and Irkutsk, on Lake Baikal, Siberian railway. For fruit breeding." (*Hansen.*)

24370 to 24401—Continued.

24379. Rubus Chameamorus L.

"(No. 95.) A wild red raspberry from vicinity of Irkutsk, near western shore of Lake Baikal, eastern Siberia. May prove useful in plant breeding." (*Hansen.*)

24380. Prunus padus L.

"(No. 7.) A wild cherry gathered by peasants and sold at steamer landing at Gorodische, on Obi River, a few miles north of Barnaul, Tomsk, western Siberia." (*Hansen.*)

24381. Prunus padus L.

(Bada.)

24382. Prunus padus L.

(Bada.)

24383. Prunus padus L.

(Bada Baikal.)

24384. Prunus domestica L.

24385. Rosa sp.

"(No. 19.) A wild rose as found between Ruchekowa and Koliwan, in northern Altai Mountain Range, southern Tomsk province, western Siberia." (*Hansen.*)

24386. Rosa sp.

"(No. 20.) A wild rose as found between Ruchekowa and Koliwan, in northern Altai Mountain Range, southern Tomsk province, western Siberia." (*Hansen.*)

24387. Rosa sp.

"(No. 47.) Wild rose from a sand desert, an arm of the Gobi desert, at station Charonte, Transbaikal region, a few miles over the Chinese border, on the Siberian railway." (*Hansen.*)

24388. Rosa sp.

"(No. 80.) A wild rose from the open steppe at Belaglasowa, southern Tomsk province, western Siberia." (*Hansen.*)

24389. Malus sp.

"(No. 36.) From village Lisinsk, Semipalatinsk province, western Siberia. Probably a variety of the Siberian crab, *Pyrus* (*Malus*) *baccata*. See No. 44 (S. P. I. No. 24390)." (*Hansen.*)

24390. Malus sp.

"(No. 44.) Same as No. 36 (S. P. I. No. 24389). Both from a lot sent to the experiment station, Omsk, Siberia." (*Hansen.*)

24391. Pyrus sp.

"(No. 45.) A small-fruited yellow pear sold by Chinese at fruit bazaar, station Manchuria, Siberian railway. Said to come from Harbin." (*Hansen.*)

24392. Malus sp.

"(No. 48.) Seeds of a medium-sized subacid apple, yellow with red blush; sold by Chinese at fruit bazaar, station Manchuria, Siberian railway. Said to be shipped from Harbin district." (*Hansen.*)

24393. Malus sp.

"(No. 49.) Same as No. 44 (S. P. I. No. 24390), but of a larger fruited variety." (*Hansen.*)

24370 to 24401—Continued.

24394. Pyrus sp.

24395. Crataegus sp. **Hawthorn.**

"(No. 62.) Native hawthorn from Irkutsk, near Lake Baikal, eastern Siberia." (*Hansen.*)

24396. Vacinnium sp.

"(No. 46.) As gathered wild near Chita, Transbaikal region, and sold on fruit bazaar. The largest fruit of blueberry type I have ever seen, averaging three or four times larger than ordinary blueberries." (*Hansen.*)

24397. Fragaria vesca L.

"(No. 2.) Seeds of a wild strawberry from near Syrastan, on the Siberian railway, western Siberia, between Zlautoust and Chelabinsk. For fruit breeding."

24398. Rubus sp.

"(No. 97.) Wild raspberry from station Bogotol, between Taiga and Krasnoyarsk, central Siberia, on Siberian railway." (*Hansen.*)

24399. Fragaria vesca L.

(St. Tajga.)

24400. Paeonia sp.

"(No. 93.) As found wild near Stretinsk, near beginning of the Amur River, Transbaikal region, eastern Siberia. Here it gets extremely cold in winter. Of interest to breeders of Pæonias." (*Hansen.*)

24401. Corylus sp.

"(No. 70.) Probably *C. heterophylla.* The wild hazelnut from near Buchedu, in the Chingan Mountains, on the Siberian railway, in western Manchuria, the farthest eastern point reached in my 1908 trip." (*Hansen.*)

24402 and 24403.

From Piracicaba, Brazil. Presented by Dr. J. W. Hart. Received February 28, 1908. Numbered for convenience in distributing December, 1908.

The following plants:

24402. Panicum muticum Forsk. **Para grass.**

Apparently distinct from the ordinary variety of Para grass grown in the United States.

24403. Capriola dactylon (L.) Kuntze. **Bermuda grass.**

This grass is grown in Brazil under the name of "*Graminaz fina.*" The variety is apparently distinct from the ordinary variety of Bermuda grass grown in the United States.

24404. Copernicia cerifera Mart. **Carnauba palm or Brazilian wax palm.**

From Piracicaba, Brazil. Presented by Dr. J. W. Hart. Received December 26, 1908.

"This tree is not native to this section of Brazil and it may be possible that these seeds will give you hardier plants than those grown in the hotter portions of the country." (*Hart.*)

"The stem of this plant furnishes starch; the sap, sugar; the leaves, a rope fiber; the pinnæ are woven into mats, hats, baskets, and brooms; the inner part of the leaf stalks serves as a substitute for cork, and most important of all the young leaves are

24404—Continued.

covered with a valuable wax harder than that of bees and used for making candles, covering phonograph cylinders, etc. Each tree furnishes about 4 pounds of wax annually." (*Adapted from Von Mueller.*)

24405 to 24413. EUCALYPTUS spp.

From Los Angeles, Cal. Purchased from Messrs. Johnson & Musser. Received December 21, 1908.

Seed of the following varieties to be tested in south Texas, Florida, and the Gulf Coast States on the recommendation of Messrs. Johnson & Musser:

24405. EUCALYPTUS CORNUTA Labill.

24406. EUCALYPTUS CLADOCALYX F. Muell.

24407. EUCALYPTUS LEUCOXYLON F. Muell.

24408. EUCALYPTUS LONGIFOLIA Link.

24409. EUCALYPTUS POLYANTHEMOS Schauer.

24410. EUCALYPTUS LONGIROSTRIS Muell.

24411. EUCALYPTUS RUDIS Endl.

24412. EUCALYPTUS SIDEROPHLOIA Benth.

24413. EUCALYPTUS VIMINALIS Labill.

24415. EUCALYPTUS ALBA Reinw.

From Buitenzorg, Java. Presented by Dr. M. Treub, director, Department of Agriculture. Received December 4 and 21, 1908.

See No. 21394 for previous introduction and descriptive note.

24416. FRAGARIA sp. **Strawberry.**

From Shanghai, Kiangsu, China. Presented by Mr. J. M. W. Farnham. Received at the Plant Introduction Garden, Chico, Cal., December 16, 1908.

White.

24417 and 24418.

From China. Received through Mr. Frank N. Meyer, agricultural explorer, at the Plant Introduction Garden, Chico, Cal., 1907; numbered for convenience in recording distribution December, 1908.

24417. CINNAMOMUM CAMPHORA (L.) Nees & Eberm. (?)

From Hangchow, Chekiang, China. "(No. 736a, June 27, 1907.) A very ornamental evergreen tree, bearing leaves like the camphor tree, but darker green and producing blue-black berries on red petioles. The Chinese chop the leaves up very fine, let them steep in water with clay or soil, and obtain a very good, weather-resisting cement in that way, especially used in plastering over old coffins which are kept standing above the ground." (*Meyer.*)

24418. SALIX BABYLONICA L.

From Fengtai, near Peking, Chihli, China. "(No. 665a, Mar. 26, 1907.) A weeping willow growing on very dry places; used as a shade tree in the streets of Peking under trying climatic and other conditions; well worth giving a trial in the western regions of the United States. Chinese name *Tsa yang liu.*" (*Meyer.*)

24419. GARCINIA sp.

From Buitenzorg, Java. Presented by Dr. M. Treub, director, Department of Agriculture. Received December 30, 1908.

Variety *pyriformis.*

24420. TRIFOLIUM SUBTERRANEUM L.

From Auckland, New Zealand. Presented by Mr. A. B. Leckenby, Central Hotel, through Mr. C. V. Piper. Received December 21, 1908.

"Abundant and useful in New Zealand." (*Leckenby.*)

24421. ANONA CHERIMOLA Mill.

From Calabria, Valley of Messina, Italy. Presented by Mr. C. Sprenger, Vomero, Naples, Italy. Received December 3, 1908.

Variety *Calabrica.*

24422 to 24428.

From Buitenzorg, Java. Presented by Dr. M. Treub, director, Department of Agriculture. Received December 28, 1908.

The following seeds:

24422. STIZOLOBIUM sp.
24423. STIZOLOBIUM sp.
24424. STIZOLOBIUM sp.
24425. MUCUNA sp.
24426. MUCUNA sp.
24427. MUCUNA sp.
24428. MUCUNA sp.

24429. CUCUMIS MELO L. **Muskmelon.**

From Odessa, Russia. Presented by Mr. Alfred W. Smith, American vice and deputy consul. Received December 28, 1908.

"This is a variety of sweet melon grown here and cultivated in several colors. It is known here as '*Kachanka*' and sometimes also called '*Tsesarka*,' on account of its spotted surface, resembling a guinea fowl's plumage." (*Smith.*)

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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 154.
B. T. GALLOWAY, *Chief of Bureau.*

FARM WATER SUPPLIES OF MINNESOTA.

BY

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AND

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IN COOPERATION WITH

THE MINNESOTA STATE BOARD OF HEALTH.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., May 10, 1909.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 154 of the series of this Bureau a paper entitled "Farm Water Supplies of Minnesota."

This paper was prepared by Mr. Karl F. Kellerman, Physiologist in Charge of Water Purification Investigations, and Mr. H. A. Whittaker, Scientific Assistant, with the informal cooperation of the Minnesota State Board of Health. The successful prosecution of this work has been due to the laboratory facilities and assistance kindly placed at our disposal by Dr. H. M. Bracken, Secretary of the Minnesota State Board of Health, and his colleagues Dr. F. F. Wesbrook, Director, and Dr. H. W. Hill, Assistant Director of the laboratories of the State Board of Health, to the skillful and conscientious technical work of Dr. A. J. Chesley in bacteriology and of Mr. M. G. Roberts in chemistry, and to the keen interest and appreciation displayed at all times by the Board as the investigations progressed.

Respectfully,
B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—471.

FARM WATER SUPPLIES OF MINNESOTA.

INTRODUCTION.

The chances of the dangerous pollution of a water supply increase as the surrounding or adjoining areas become more and more thickly settled, and, very naturally, the theories and methods of the sanitary control of water supplies have been developed in cities and from the standpoint of a congested population. It is becoming apparent, however, that even in this country, with its comparatively recent occupation and sparse rural settlement, both farm and city are suffering from the careless management of rural sanitation.

Two recent examples of this fact may serve more effectively to emphasize the moral that it is necessary to learn immediately whether dangerous sanitary conditions exist generally throughout the rural districts of the United States and to discover means of controlling or preventing such pollution. The first example is the prevalence of typhoid in the city of Washington, D. C., in spite of the fact that the water supply is filtered and of good character.[a] The inference seems clear that this unfortunate condition is due to the presence of typhoid cases on the farms supplying dairy and other products.

The second example is the report of the very high percentage of typhoid fever cases in some of the rural districts of Maryland, reaching two and one-half times the percentage found in Baltimore, the largest city in that State.[b]

While it is recognized that in only a limited percentage of cases can typhoid fever in rural districts be traced directly to the farm water, the condition of each supply fairly typifies the general conditions of hygiene and sanitation upon the respective farms. Evidently, then, the study of farm supplies involves many problems in addition to the examination of the water actually in use. A complete sanitary survey of some representative area of considerable extent with a thorough investigation of all the factors bearing upon each and all of the supplies is necessary before intelligent recommendations for improvement can be made. Unfortunately such studies[a] have not covered a sufficiently large area nor have a sufficient variety of methods been employed to meet these exacting requirements. Adequate knowledge of a single farm supply may require a study of the conditions of a rural home and its surroundings, and occasionally include the epidemiology of an entire neighborhood.

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[a] Rosenau, M. J., Lumsden, L. L., and Kastle, J. H. Report on the Origin and Prevalence of Typhoid Fever in the District of Columbia. Public Health and Marine Hospital Service, Hygienic Laboratory, Bul. 35. 1907.

Horton, T. The Prevalence and Causation of Typhoid Fever in Washington, D. C. Engineering News, vol. 56, No. 19, pp. 484–488. 1906.

Sedgwick, W. T. Comments upon Mr. Horton's Report and upon the Typhoid Fever Situation in the District of Columbia. Engineering News, vol. 56, No. 19, pp. 488–489. 1906.

The Causes of Typhoid Fever in the District of Columbia. Washington Medical Annals, vol. 7, pp. 33–122. 1908.

Magruder, G. Lloyd. Typhoid Fever in the District of Columbia. Washington Medical Annals, vol. 6, No. 1, pp. 69–71. Mar., 1907.

[b] Cited from Maryland Medical Journal by Dr. G. Lloyd Magruder. Washington Medical Annals, vol. 6, No. 1, March, 1907.

The scope of the investigations here presented is limited to a single State. This State, Minnesota, exhibits a wide range of rural conditions both from the economic point of view regarding mineral and agricultural resources and from the purely agronomic point of view regarding the variety of natural and cultural features incident to factors of climate, topography, geology, and relative age of settlement.

THE SELECTION OF SECTIONS FOR INVESTIGATION.

In the investigation of large sections of the country it is highly desirable to discriminate intelligently in the selection of the districts to be examined. The knowledge of the investigator preceding the investigation of a rural territory should include at least general information of the data available on its topography, geology, and hydrology.

The variation in these features makes possible the selection of certain typical sections which may fairly be compared with each other. It is, however, necessary at times to make examinations purely for epidemiological purposes even if this requires the duplication of certain lines of investigation.

The economic development of the territory is worthy of attention, and in interpreting data it must be kept constantly in mind, as it deals directly with the distribution of population, wealth, and resources.

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[a] The Water Supply. Oklahoma Agricultural Experiment Station, Bul. 66. 1905.

Miscellaneous Water Analyses. Oklahoma Agricultural Experiment Station, Bul. 67. 1905.

Palmer, A. W. Chemical Survey of the Water Supplies of Illinois. Report for the Years 1897–1902. University of Illinois. 1903.

Ladd, E. F. Waters of North Dakota. North Dakota Agricultural Experiment Station, Bul. 66. 1905.

Bartow, Edward. Chemical and Biological Survey of the Waters of Illinois. University of Illinois, Report for the Year Ending August 31, 1906, and Report, September 1, 1906, to December 31, 1907.

Dole, R. B., and Wesbrook, F. F. The Quality of Surface Waters in Minnesota. U. S. Geological Survey Bul., Water-Supply and Irrigation Paper No. 193. 1907.

The distribution of these factors has a marked influence upon the sanitary condition of any community, as well as upon the feasibility of urging expenditures when improvements are desirable. This is especially noticeable in the field of epidemiology when the investigator is dealing directly with the source and transmission of a disease.

TYPES OF FARM WATER SUPPLIES WITH REFERENCE TO FACTORS OF POLLUTION.

Farm water supplies can be divided into two fairly distinct classes—underground and surface. The underground supplies consist of dug wells, bored wells, drilled wells, driven wells, and springs; the surface supplies consist of rivers, lakes, surface reservoirs, and cisterns. In Minnesota the supply in most general use is perhaps the dug well, although the ratio of the different types varies with the location. Springs are used to a limited extent, usually in cases where their location is convenient. The use of surface supplies [a] varies with the locality and depends mainly upon the availability or character of the underground supply.

The dug well, probably the oldest type of well known, is usually a round or square excavation several square feet in area, the depth varying in different localities according to the distance of the water-bearing stratum from the surface of the earth. Its construction varies widely in different localities. The crudest form of a dug well consists of a shallow hole in the ground which collects water both from the surface and from the upper layers of the soil and has no covering to serve as a protection. Water from such a well is usually dipped, either directly or by means of a rope and bucket. In such a well no attempt whatever is made to protect the water from pollution. In the development of the deeper dug wells necessity demanded the use of a casing to hold back the soil, and various materials have been used for this purpose. In pioneer settlements logs are sometimes used, while in many regions boards are found. Modern casings [b] include a number of materials, such as stone, brick, cement, concrete, and tile, installed in various ways. Casings are now meant to serve as a protection from surface pollution in addition to holding back the soil; therefore, not only the use of suitable material but also the proper installation of that material is of the utmost importance.

Certain methods of drawing water from a dug well afford avenues for pollution of surface origin. The old style of drawing water by means of a chain or rope and bucket is undoubtedly a dangerous one; most of the wells equipped in this way are entirely uncovered, permitting the entrance of various kinds of organic and inorganic matter, and as the bucket on leaving the hands of the operator passes directly into the water an opportunity is given for polluting the well should the hands of the operator be infected. The ordinary type of iron pump is usually safe, although the so-called "priming" of pumps affords an opportunity for direct infection if the priming water or the vessel containing it is infected.

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[a] Dole, R. B., and Wesbrook, F. F., loc. cit.

[b] For antiquity of wells and casings, see J. G. Swindell and G. R. Burnell, Well-Sinking, pp. 1–5. London, 1886.

The covering of a dug well is also of great importance, and if tightly joined to the casing may prevent the entrance of surface pollution. Wood is used almost entirely for this purpose, but on account of the frequent wetting and drying to which most coverings are subjected, crevices soon form between the boards and foreign matter is admitted with the waste water from the pump. The covering of a well should be kept as dry as possible, and the surface immediately surrounding a well should slope away in all directions, in order to form a protection from surface water.

The bored well is used to a limited extent in various localities and is dug with machines made for that purpose. It differs from the dug well principally in size, the total area of the ordinary bored well being about one square foot. The casing used for this type of well is made of wood, tile, or tin. The tin casing used in certain sections is simply a soldered tin pipe extending the entire depth of the well. Long slender buckets with loose bottoms are used for drawing the water where the method of drawing is confined to the rope and bucket. The bored well is subject to practically the same criticisms of construction as the dug well. The area of surface exposed to external polluting influences is much smaller, yet it should be protected in the same careful manner recommended in the case of the dug well.

The drilled well, as the name signifies, is installed by means of a drilling apparatus. This type is usually found in sections where water is obtained only at a considerable depth and where the penetration of rock or some other hard stratum is necessary. The size of the shaft varies from about two inches to several feet.[a] The casing in some wells extends to the bottom and in others only to the rock formation, beyond which point the rock itself serves this purpose; the casing usually meets the base of the pump above the surface of the ground.

If a well pit has been excavated the casing extends only into that. In any case it should be tightly covered in order to prevent the entrance of surface pollution. Drilled wells very frequently have well pits which are about the size of a dug well and are from 8 to 12 feet in depth. Well pits 8 to 12 feet in depth and 3 to 4 feet in diameter are often sunk around the shaft for the purpose of protecting parts of the pumping apparatus from frost, and at times are a prominent factor in the pollution of a well, serving as catch basins for polluted water of recent surface origin. The depth of some wells is increased by driving or drilling. In these cases the dug portion really serves as a well pit and should be carefully protected against pollution.

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[a] Vernon-Harcourt, L. F. Sanitary Engineering, pp. 62–78. London, 1907.

The driven well, a type of supply first used at the beginning of the nineteenth century,[a] is usually found in localities where water is secured relatively near the surface. The casing consists of sections of iron pipe screwed into couplings so as to be continuous and water-tight throughout. The lower end of the pipe is armed with a sharp metallic point perforated with holes, which serves as a penetrating instrument during driving, and prevents the soil from entering the pipe. The iron pipe used for casing is usually about 2 inches in diameter, but varies in size from 1¼ to 10 inches.[b] Well pits are even more common with the driven than with the drilled well. In the driven well the shaft is usually not large enough to inclose the part of the pump which requires protection from frost, and a well pit is practically necessary with the ordinary type of iron pump. The driven well requires less care and is probably as safe as any type of moderately shallow supply.[c]

Springs are used to a limited extent as a source of farm water supply, their use depending mainly upon their convenience. A spring often may be made a safe supply by carefully protecting it against surface pollution, although in general the same factors influencing the safety of dug wells should receive consideration.

Cisterns are a very common form of farm water supply in certain localities where the underground water is hard to obtain or is unfit for use; historically they are perhaps the oldest form of artificial supply.[d] They are used for the storage of water from various sources, but usually for rain water. They may be constructed of brick and mortar, concrete, stone, etc., usually underground, or of galvanized iron, and placed wherever convenient. If well located and protected, the latter type should be satisfactory. The temptation is great, however, to locate this type on the surface, and in this case the temperature of the cistern water during the summer season is much higher than that in the underground type, and the growth of organisms, which are usually present in waters collected from roofs, is encouraged rather than discouraged. A roof which is the catchment area for cistern water may also collect anything carried in the air. The character of the materials deposited will of course depend upon the section of the country and the season of the year. Some of the most common are dust, dead insects, excreta from fowls of the air, seeds and spores of plants, and even vegetable growths. Sometimes a roof is constructed of material which can be partially extracted by rain water, and the solution thus formed becomes very objectionable at times, especially if the water collected is to be used for drinking purposes.

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[a] Olshausen, J. Schlagbrunnen. Gesundheits Ingenieur, 23. Jahrg., No. 17, pp. 278–280. 1900.

Sinking Driven Wells. Engineering Record, vol. 40, pp. 362–363. 1899.

Noyes, A. F. The Driven-Well System as a Source of or a Means of Obtaining a Water Supply. The Sanitary Engineer and Construction Record, vol. 16, pp. 264–265. 1887.

[b] Sinking Driven Wells. Engineering Record, vol. 40, pp. 362–363. 1899. See also Vernon-Harcourt, loc. cit., p. 48.

[c] Sutcliff, R. "Abyssinian" Tube Wells. Cited from Journal of Society of Arts by Van Nostrand's Engineering Magazine, vol. 23, pp. 281–285. 1880.

[d] Larousse, P. Citerne. Grand Dictionnaire Universel, vol. 4.

After the water enters the cistern proper the opportunities for pollution depend mainly upon the construction and protection of the type of cistern in use. Leaks probably offer one of the greatest opportunities for pollution if the cisterns are located beneath the surface; in this case ground water is often given free entrance. Ground water in the neighborhood of cisterns is not infrequently polluted, for in its passage through the small amount of surface soil usually covering a cistern very little purification is effected. Priming is usually necessary in cistern pumps, and when water-borne diseases are present in the home this practice may prove a very dangerous factor in the transmission of disease. The quality of cistern water can be much improved by installing a device for turning away the water caught during the first part of a shower; this secures a thorough washing of the roof before any water enters the cistern.

Surface reservoirs are built in certain farming sections[a] for collecting and holding surface water. The construction of the ordinary type is very simple. A portion of the surface soil is removed, which leaves a depression for collecting water from a small natural or artificial catchment area. These reservoirs are usually located in a more or less impervious soil, although clay is sometimes used to line a reservoir which would not otherwise hold water. Water for domestic purposes is either dipped or pumped from these reservoirs. When pumps are used they are suspended on a platform built over the water which is connected with the shore by a board walk. The purity of such a supply depends mainly upon the protection of the area from which the supply is collected; the season will also influence the condition of the water, depending upon the temperature, rain, snow, wind, and other atmospheric conditions.

Rivers and lakes are used to a very limited extent as a source of drinking water for farms in Minnesota. Their potability depends almost entirely upon the environment of the individual lake or river in question. The pollution includes principally waste material contributed by thickly populated communities. In rural communities rivers and lakes are used more extensively during the winter season, the temperature at that time making the water more palatable, although probably no less dangerous.

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[a] In Kittson County, Minn., this practice is common.

METHODS OF COLLECTION AND EXAMINATION OF WATER SUPPLIES.

The selection of farms for illustrating various conditions of rural sanitation is best made by actual observation and from information secured in the field. If possible, several types of water supplies are chosen in each community, though these selections are of course influenced by the sanitary environment of the different types, more time being given to the investigation of unsatisfactory conditions. The data secured in the present investigation and recorded in the field are grouped under three general headings: (1) Identification data; (2) general and structural water data; and (3) general sanitary and epidemiological data. The laboratory determinations are reported in Table IV, pages 78 and 79.

The identification data for various reasons have been sufficiently abridged so that only the general location of the farms under discussion can be determined.

The general sanitary and epidemiological data may be of direct or indirect interest in reference to the water supply, but in either case include a concise statement of the apparent character of the supply. This statement may or may not uphold the results of the analysis of the samples of water collected, but is essential for interpreting correctly the chemical and bacteriological data.

The collection of field data and samples of water was made by Mr. H. A. Whittaker, representative of the Bureau of Plant Industry. Both chemical and bacteriological samples were taken from each supply investigated and were shipped immediately to the laboratories of the Minnesota State Board of Health for examination. The chemical and physical analyses were made partly by Mr. M. G. Roberts, of the State Board of Health, and partly by Mr. Whittaker, in accordance with the recommendations of the committee on standard methods of water analysis of the American Public Health Association. The bacteriological counts and the tests for *Bacillus coli* were made by Dr. A. J. Chesley, of the State Board of Health laboratories. The method used in examination followed the recommendations of the committee mentioned, with the following exceptions:

(1) Agar was used instead of gelatin for counts.

(2) Incubation was at room temperature and for four days from time of plating. If less than four days were established as a limit, plates would often be received in the laboratory so long after plating that the allowed incubation period would already have been exhausted in transit.

(3) The colon tests recommended alternatively as procedure A and procedure B by the committee on standard methods of water analysis of the American Public Health Association were both employed, the former on 100 c. c. samples enriched by quadruple strength broth and incubated; the latter on 1 c. c. samples prepared in the field, which is also an enrichment method.[a]

(4) The preparation of media followed strictly the committee's recommendations except in the following details:

Plain nutrient broth. Sterilized in an autoclave.

Dextrose broth. The muscle sugar removed.

Milk. Owing to variability of ordinary milk the following substitute was used: Nutrose (sodium-phosphate-casein) 2.6 grams, lactose 1 gram, distilled water 100 c. c. Heat to dissolve casein, but *do not boil;* filter, tube, and autoclave fifteen minutes at 15 pounds.

Potato. Not prescribed by the committee. This is prepared by cutting diagonal half cylinders from good fresh potatoes and washing over night to remove acidity. The half cylinders were dropped large end down into test tubes containing wet cotton at the bottom. The potato tubes were autoclaved.

The order of procedure in the adjustment of acidity in nutrient agar and gelatin media was slightly changed.[b]

(5) From all the dilutions made those plates were selected which yielded counts of not much above 200, all that were higher or lower being disregarded. If deep well waters or other waters normally showed counts below 40 to each cubic centimeter, several plates were made and the results averaged.

The traveling laboratory case designed by Dr. H. W. Hill, Assistant Director of the Minnesota State Board of Health Laboratories, as an improvement on the field outfit formerly in use for sanitary studies of water supplies, is very complete and satisfactory for work of this character, and at our request Doctor Hill has furnished the following description:

The traveling laboratory case is a box made of half-inch pine, 18¼ inches long, 6¾ inches wide, and 16¾ inches high, outside dimensions. The front opens on strap hinges at the base. The top is supplied with a comfortable handle and opens on strap hinges at the back; it carries a hinged iron strap, which engages with a staple on the front and is secured with a padlock. The box is treated inside and out with anilin black, and the corners are protected by trunk shoulder plates.

A half-inch horizontal partition divides the box into two sets of compartments. The lower set consists of three compartments 8 inches high and 6 inches deep; two of these, adjoining, are 5 inches wide; the third is 6¼ inches wide. The 5-inch compartments each carry ten Petri dishes, which are wrapped in filter paper before sterilization to exclude dust and to prevent breakage in transit. The third compartment carries a Barthel alcohol lamp, and inverted over the lamp is a copper dish (4 inches in diameter, 5 inches high), for boiling water to melt agar media, and a tripod for supporting the dish on the stem of the lamp. A small bottle for extra alcohol and one or two towels also fit into this compartment. The upper set consists of one large compartment 6 inches deep, 7 inches high, and 10½ inches wide, and a small one 6 inches deep, 7 inches high, and 6¼ inches wide. The small compartment carries six cylindrical 4-ounce glass-stoppered collecting bottles and two rectangular 5-ounce rubber-stoppered bottles for sterile dilution water. The large compartment contains two wooden test-tube racks, supported by vertical guides at the ends, and constructed of ¼-inch pine as follows: From the center line of a flat wooden base (1½ inches wide and 10 inches long) rises a flat sheet of wood (5 inches high and 10½ inches long); narrow vertical strips of wood at each end of each side of this sheet coapt with the vertical guides on the ends of the compartment, leaving a narrow edge of the ends of the sheet exposed to slide in the slots of the guides. Two pins in each vertical strip permit rubber bands to be stretched across each side of each sheet from end to end. The test tubes are inserted between the sheet and the rubber bands on each side of the sheet, resting on the wooden base. Each rack carries about twenty test tubes. The floor of this compartment next to the back of the box is cut away along its whole length for a width of 1⅛ inches; through this opening pass pipette cases containing two thermometers and about twenty pipettes, four pipettes to a case. Between the racks is space for an envelope containing gummed labels, spare elastics, a lead pencil, a glass pencil, etc., and cards for recording data on samples collected.

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[a] Wesbrook, F. F. Laboratory Methods and Devices. Journal of Infectious Diseases, Supplement No. 1, pp. 322–323. 1905.

[b] Hill, H. W. Suggestions for Changes in the Schedules for Making Broth, Gelatin, and Agar, etc. Journal of Infectious Diseases, Supplement No. 2, pp. 223–225. Feb., 1906.

APPARATUS.

Petri dishes.—Twenty to twenty-two standard 4-inch dishes with porous tops.

Test tubes.—Forty to forty-five standard 6-inch by ¾-inch tubes; twenty to twenty-two containing 10 c. c. each of standard agar for plating, the remainder plugged and sterilized but empty, for making dilutions, etc.

Pipettes.—Six cases of four 1 c. c. pipettes each; one case containing 5 c. c. pipettes.

DESCRIPTION OF THE WATER SUPPLIES EXAMINED.

In the course of the present investigation 28 dug wells, 6 bored wells, 13 drilled wells, 19 driven wells, 2 springs, 1 river,[a] 2 surface reservoirs, and 5 cisterns were examined. A brief statement of the sanitary condition of each supply is made, based partly upon the data secured from the chemical and bacteriological studies of water samples and partly upon the conditions shown by the sanitary inspection of the environment of the various supplies.

The identification of supplies as either good or polluted can be made only by laboratory investigations upon properly collected fresh samples of the water, together with a personal inspection by a trained expert of the environment of the supply.

Further explanation is perhaps desirable regarding the use of the terms "good" and "polluted" in the following descriptions of the various water supplies. A water supply to be described as good must be so located that the apparent possibilities of dangerous pollution are remote, and the samples of water taken for laboratory study must conform to the definition[b] of a pure and wholesome water:

> Unquestionably the term "pure and wholesome water" as ordinarily used relates to water intended to be used for drinking. Such a water must be free from all poisonous substances, as the salts of lead; it must be free from bacteria or other organisms

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[a] The Red Lake River, on which four of the supplies examined were located.

[b] Whipple, George C. The Value of Pure Water, pp. 3–4. New York, 1907.

liable to cause disease, such as the bacilli of typhoid fever or dysentery; it must also be free from bacteria of fecal origin, such as *B. coli*. In other words, the water must be free from poisonous substances, from infection, and even from contamination. By this term is meant pollution with fecal matter. Contamination must be considered as potential infection. Besides this, it must be practically clear, colorless, odorless, and reasonably free from objectionable chemical salts in solution and from microscopic organisms in suspension. Moreover, it must be well aerated. Color, turbidity, odor, dissolved salts, etc., may be permissible to a small degree without throwing the water outside of the definition of pure and wholesome waters. In these minor matters local standards govern up to a certain point, and it is in regard to them that differences in judgment and experience of analysts lead to diverse classifications.

Dug well No. 7 illustrates these conditions. The environment of the well appears reasonably safe even though it is not entirely satisfactory, and the analytical data secured from the water samples indicate a good water both chemically and bacteriologically. Dug well No. 10 shows the opposite conditions; the environment is very unsatisfactory, and the laboratory studies show that the water is polluted.

In the following descriptions of the sanitary condition of the water supplies examined upon various farms, the location of the farms, for obvious reasons, is shown only in an approximate way. Arrows are used in the accompanying sketches to show the slope of the ground.

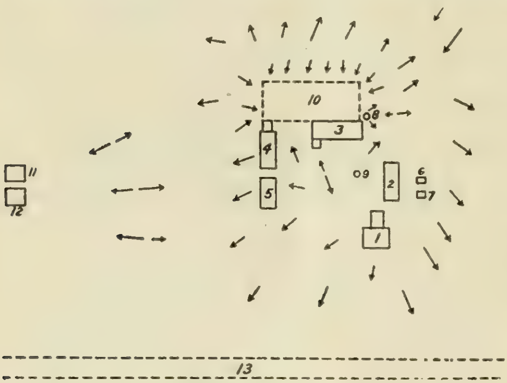

FIG. 1.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 1: 1, Farmhouse; 2, stone house; 3, hay barn with basement; 4, chicken house; 5, granary; 6, storehouse; 7, privy; 8, dug well; 9, drilled well; 10, barnyard; 11, hay barn; 12, hay barn; 13, public road.

DUG WELLS.

No. 1. A polluted supply. The dug well should be abandoned and water taken from the drilled well.

Location of farm.—Merriam Park, Minn.

Date of visit.—July 3, 1908.

Size.—Eighty acres.

Kind of farming.—General.

Topography.—In general, slope of ground is away from house and from most of the outbuildings. The barnyard slopes in the direction of the basement stable.

Source of water supply.—(See fig. 1.) The well in use is adjacent to the stable and barnyard; 28 feet in depth; casing, brick. The unused well, which is of the drilled type, is located midway between the house and stable, 140 feet deep, with a 3-inch iron casing well protected at surface. *Strata:* Dug well (No. 8), 23 feet surface clay and 5 feet sand; drilled well (No. 9), 130 feet surface clay and hardpan, 5 feet rock, and 5 feet gravel. *Yield:* Dug well, abundant during wet season; drilled well, abundant at all seasons. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Dug well (No. 8) is only 15 feet from barnyard; however, surface of well is raised about 5 feet above level of yard. The barnyard unfortunately has no drain, and the surface of the yard is covered with a saturated mixture of water and manure most of the year. The danger to the shallow well is increased from the fact that the supply at times is scarcely adequate. The possibilities of polluting the drilled well (No. 9) from its surroundings are limited on account of its depth and surface protection. This well would undoubtedly make the safest supply, but as more effort is required to pump the water from a depth of 140 feet and because of the added objection of a slight iron taste, it has been almost entirely abandoned; it is now used only in case the supply in the dug well is insufficient.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stables poor; privy poor, unprotected vault.

Milk.—Used on farm. Sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 2. A polluted supply. It would be impracticable to attempt to obtain a potable supply from this well.

Location of farm.—Minneapolis, Minn.

Date of visit.—July 8, 1908.

Size.—Thirty-six acres.

Kind of farming.—Dairy.

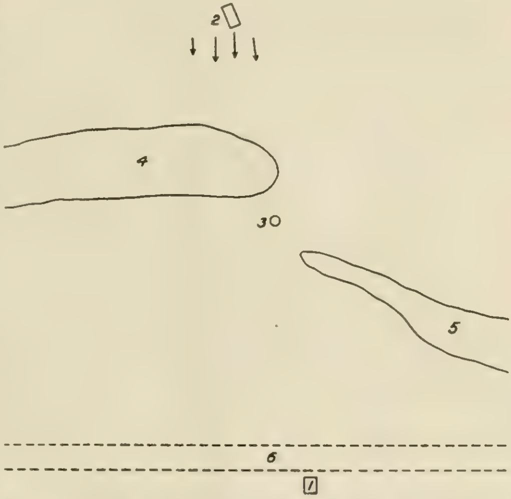

FIG. 2.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 2: 1, House; 2, barn and stables; 3, well; 4, pond; 5, pond; 6, street.

Topography.—The well is in the center of a marshy field about 20 rods from the house and barn. The barn is on dry land elevated several feet above the marsh. The slope from the house to the well is very gradual.

Source of water supply.—(See fig. 2.) The well is in the center of a marshy field surrounded by ponds; 15 feet in depth; casing, wood. *Strata:* Soft marsh soil. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* The well is probably in the poorest location possible to select, and its mouth has little protection from surface washings. Cattle make the well a resting place and considerable manure is deposited about the well ready to be carried in by surface washings.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Several ponds adjacent to well. The surface of these ponds is partly covered with a green growth, the odor from which would indicate very stagnant water. Some of the water in these ponds undoubtedly finds its way into the well.

Sanitary condition of farmhouse and outbuildings.—House fair; stables poor; manure is thrown out on two sides of the stable and the leachings flow back under the stable floor; privy poor, unprotected vault.

Milk.—Retailed in city; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 3. A slightly polluted supply. This pollution could be avoided by installing a good casing and a tight covering.

Location of farm.—St. Paul, Minn.

Date of visit.—July 16, 1908.

Size.—Twelve acres; 2 owned and 10 rented.

Kind of farming.—Dairy.

Topography.—The house is located on the highest ground, the elevation being about 5 feet above the well and outbuildings.

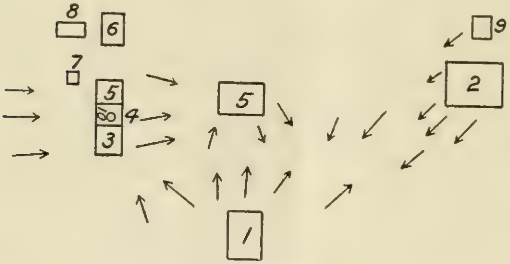

FIG. 3.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 3: 1, House; 2, stables; 3, wagon shed; 4, pump house; 5, tool shed; 6, ice house; 7, privy; 8, hogpen; 9, chicken house; 10, well.

Source of water supply.—(See fig. 3.) The well is in a protecting shed; 80 feet in depth; casing, 1½-inch planks; area of well, 3 square feet. *Strata:* Unknown. *Yield:* Abundant. *Method of lifting:* Iron pump; windmill for power. *Sanitary aspect:* Poor. The casing near the surface is loose and affords opportunity for entrance of surface water. The well cover appeared very unclean, as the pump house had been used for sheltering chickens.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House and stables fair; privy poor, unprotected vault.

Milk.—Retailed in city; sanitary care poor.

Water-borne diseases.—The owner of the farm had a severe case of typhoid two years previous to the date of visit. He was accustomed to visit the city of St. Paul daily. The entire family drank this well water at the time, but no others became infected. It would seem reasonable to suppose that the fever was contracted elsewhere than on the farm.

Analyses.—See page 78.

No. 4. A polluted supply. This supply could be very much improved by the installation of proper casing, covering, and pump.

Location of farm.—St. Paul, Minn.

Date of visit.—July 16, 1908.

Size.—One hundred and forty acres.

Kind of farming.—General.

Topography.—The general slope of the ground is away from the house in the direction of the stables. The house is 3 feet above the mouth of the well and about 8 feet above the outbuildings, and a pond is on a still higher elevation.

Source of water supply.—(See fig. 4.) The well is about 20 feet from the house and 30 feet from a marshy pond; 38 feet in depth, 3 feet square; casing, $1\frac{1}{2}$-inch wood planks. *Strata:* Clay, 28 feet, and sandy gravel, 10 feet. *Yield:* Abundant in summer, but scanty during the winter. This would seem to indicate that the well was drawing from the pond, as this source of supply would be cut off during the winter. *Use:* Drinking and general farm purposes. *Method of lifting:* Old-fashioned bucket, pulley, and rope. *Sanitary aspect:* The well is dangerously located. The house is only 21 feet away and on a higher level; a stagnant marshy pond is within 30 feet on a higher level; the unprotected privy vault is on the same level and within 35 feet. The mouth of the well is protected only with the usual slant-roof covering of bucket wells. At high-water periods the pond overflows and forms a stream not 15 feet from the well. The casing does not extend above the surface of the ground.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—A marshy pond filled with stagnant water during the entire year.

Sanitary condition of farmhouse and outbuildings.—Very poor in every way.

Milk.—Used on farm; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 5. A slightly polluted supply. The character of the water could undoubtedly be improved by better surface protection.

Location of farm.—St. Paul, Minn.

Date of visit.—July 17, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—General.

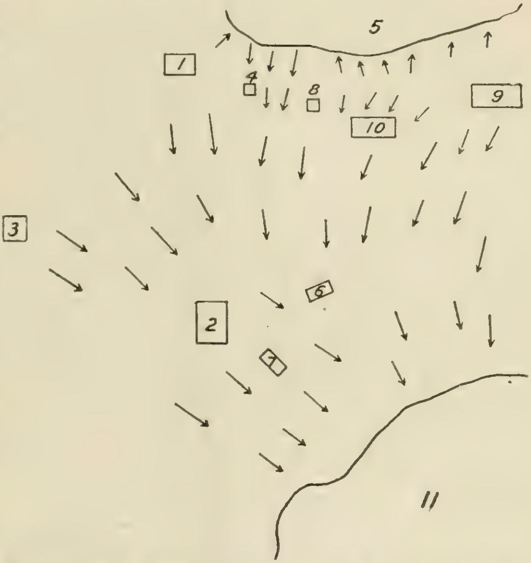

FIG. 4.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 4: 1, House; 2, stables; 3, granary; 4, well; 5, pond; 6, chicken house; 7, chicken house; 8, privy; 9, hogpen; 10, cow stable; 11, pond.

Topography.—The ground slopes away from the house in all directions. The house is 3 feet above the barn and 14 feet above the well. The slope from north to south is quite gradual at first and then becomes very abrupt.

Source of water supply.—(See fig. 5.) The well is 200 feet from the stables and approximately 400 feet from the house. It was originally an ordinary dug well, but later a 12-inch tile casing was placed down the entire depth of the well and stones of various size filled around it The well is 25 feet deep. *Strata:* Clay entire depth. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Ordinary wooden pump with wooden pipe extending to the bottom of the well. *Sanitary aspect:* Fair. The tile casing extends above the surface, but does not exclude the danger of seepage through the loose stone filling surrounding the tile. *Abandoned well:* A well (No. 9) 160 feet deep was abandoned some years ago on account of a bad odor, excessive iron, and extreme hardness of the water.

Cisterns: One, used for drinking and washing purposes; contains a filter wall and appears to be in good condition.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House in exceptionally good condition; stables well cared for; privy poor; unprotected vault.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—No record of any having occurred in recent years.

Analyses.—See page 78.

No. 6. Probably a polluted water, although the bacteriological data are lacking. This supply could undoubtedly be made safe by installing a pump, extending the casing above the surface, and banking and trenching to protect from surface pollution.

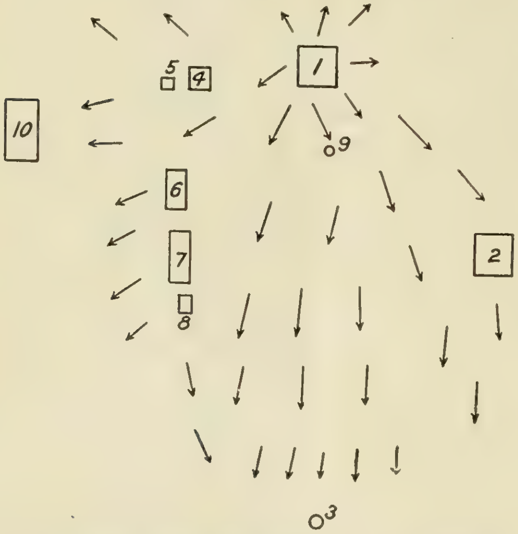

FIG. 5.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 5: 1, House; 2, barn; 3, well; 4, ice house; 5, privy; 6, wagon shed; 7, granary; 8, chicken coop; 9, abandoned well; 10, hay barn.

Location of farm.—Gladstone, Minn.

Date of visit.—July 20, 1908.

Size.—Thirteen acres.

Kind of farming.—General.

Topography.—The slope of the ground is generally in one direction; the total fall between privy and stable, a distance of about 150 feet, is about 10 feet.

Source of water supply.—(See fig. 6.) The well is midway between the house and the stables; 22 feet deep, wooden casing. *Strata:* Clay, 9 feet, and sand, 13 feet. *Yield.*—Abundant. *Use:* Drinking and general farm purposes. *Method of lifting.*—Rope and bucket. *Sanitary aspect:* Bad; no protection whatever has been provided against surface wash and the well seems to be in bad condition.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—One small lake; also a creek leading into lake.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor; privy poor, unprotected vault.

Milk.—None.

Water-borne diseases.—One case of typhoid thirteen years ago, at which time a different water supply was used.

Analyses.—See page 78.

No. 7. A good water. The mouth of the well should be protected from surface wash, and a good casing and covering should be installed. In its present condition the supply is in danger of pollution.

Location of farm.—Gladstone, Minn.

Date of visit.—July 18, 1908.

Size.—Seventy-five acres.

Kind of farming.—Dairy.

Topography.—The slope of the ground is away from the house in all directions. The well is 3 feet lower than the house, and the stables are about 5 feet lower than the well.

Source of water supply.—(See fig. 7.) The well is covered by the pump house; 20 feet in depth; casing, ordinary 1½-inch planks. *Strata:* Gravel and clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Ordinary iron pump; windmill used for power. *Sanitary aspect:* Fair. The location is slightly below that of the surrounding ground and the mouth of the well has no protection from surface wash. Slop from the milk house is thrown on the ground near the well and undoubtedly finds its way into the well.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Several small ponds; one small marshy pond about 20 rods back of house.

Sanitary condition of farmhouse and outbuildings.—House good; milk house fair; stables poor; privy poor, unprotected vault.

Milk.—Retailed in St. Paul; sanitary care fair.

Water-borne diseases.—No record of any for the past three years.

Analyses.—See page 78.

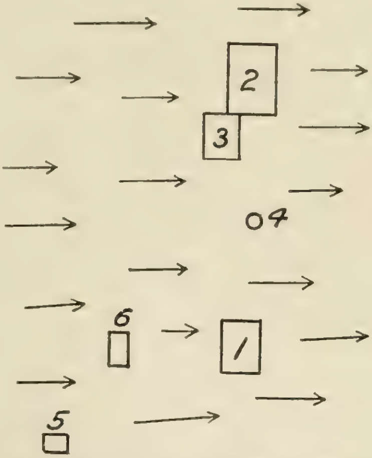

FIG. 6.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 6: 1, House; 2, barn and stables; 3, wagon shed; 4, well; 5, privy; 6, woodshed.

No. 8. A polluted supply. It is possible that this supply could be protected from pollution if a tight casing was installed; however, owing to the dangerous location and shallow depth of the well this is doubtful.

Location of farm.—Hastings, Minn.

Date of visit.—July 22, 1908.

Size.—One hundred and twenty acres.

Kind of farming.—General.

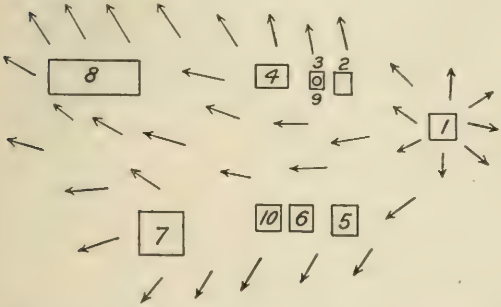

FIG. 7.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 7: 1, House; 2, milk house; 3, pump house; 4, wagon shed; 5, tool shed; 6, ice house; 7, horse barn; 8, cow stable; 9, well; 10, wagon shed.

Topography.—The surface slopes from the house in the direction of the well and outbuildings.

Source of water supply.—(See fig. 8.) The well is about 15 feet from the barnyard on low ground; 18 feet deep; casing, uncemented stone. *Strata:* Gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair; well too near the barnyard. The surface is well protected with tightly matched heavy planks. The mouth of the well is raised about 6 inches above the cement floor of the pump house.

Cisterns.—Used for washing only.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—Exceptionally good.

Milk.—Skimmed milk used on farm; cream shipped to St. Paul; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 9. The cistern supply is polluted. The well is satisfactory and should be used for direct supply where water of good sanitary quality is needed.

Location of farm.—Hastings, Minn.

Date of visit. July 22, 1908.

Size.—Forty acres.

Kind of farming.—Dairy and general.

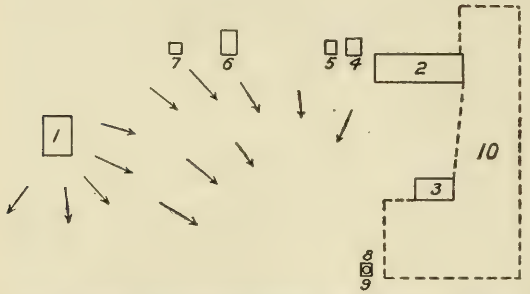

Fig. 8.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 8: 1, House; 2, stables; 3, stone house; 4, granary; 5, corncrib; 6, ice house; 7, privy; 8, pump and milk house; 9, well; 10, barnyard.

Topography.—The house is about 35 feet from the well and about 3 feet higher; the general slope is in the direction of the outbuildings.

Source of water supply.—(See fig. 9.) The well is 35 feet from the house and 20 feet from the stables; after digging the well a 6-inch tile casing was installed and the well filled; 127 feet in depth. *Strata:* Mixture of sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump; windmill used for power. *Sanitary aspect:* Well fair; cistern poor.

Cisterns.—Well cistern located at corner of stable about 15 feet from the well; circular, with flat bottom and arched top, cement bottom, sides, and top; capacity, 75 barrels. The water is pumped from the well into the cistern as a reserve supply in case the windmill fails to pump. Almost the entire supply, drinking included, is used from this cistern. An ordinary iron hand pump is used to draw water.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—Good.

Milk.—Retailed in city; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

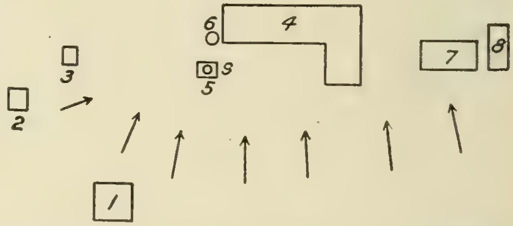

Fig. 9.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 9: 1, House; 2, ice house; 3, privy; 4, stables; 5, milk and pump house; 6, cistern well; 7, chicken coop; 8, hogpen; 9, well.

No. 10. A polluted supply. The well should be condemned for domestic use and another sunk in a more suitable place.

Location of farm.—Red Wing, Minn.

Date of visit.—July 23, 1908.

Size.—One hundred and three and one-half acres.

Kind of farming.—Dairy.

Topography.—The entire drainage from all the buildings and the barnyard reaches the well, which is about 12 feet below the highest point of the yard.

Source of water supply.—(See fig. 10.) Well at corner of barnyard; 15 feet in depth; casing, uncemented stone. *Strata:* Ordinary black marshy soil. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, though on date of visit the pump was out of order and the water was drawn with a rope and tin pail. *Sanitary aspect:* Bad; surface wash from the entire barnyard and stables has ample opportunity for reaching the well in case of heavy rain. The unprotected privy vault is located above the well. The ground surrounding the well is marshy and is flooded during the spring season of the year.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Many springs in the marshy section on which the well is located. Hay Creek, a small stream, flows through the marsh 10 to 15 rods from the well.

Sanitary condition of farmhouse and outbuildings.—House good; stables poor; privy poor, unprotected vault.

Milk.—Retailed in city; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

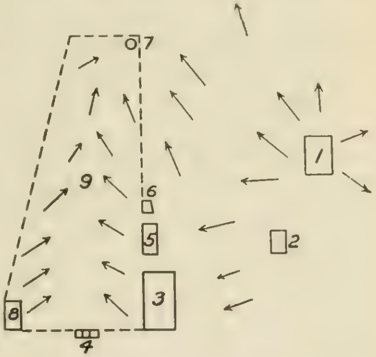

FIG. 10.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 10: 1, House; 2, wood shed; 3, barn and stables; 4, bridge; 5, milk house and corncrib; 6, privy; 7, well; 8, hogpen; 9, barnyard.

No. 11. A polluted supply. This well might furnish a good supply if great care was taken in protecting it from both surface and underground pollution by installing a proper casing and a tight covering.

Location of farm.—Red Wing, Minn.

Date of visit.—July 24, 1908.

Size.—Three acres.

Kind of farming.—General.

Topography.—Level of well about 1 foot below that of house.

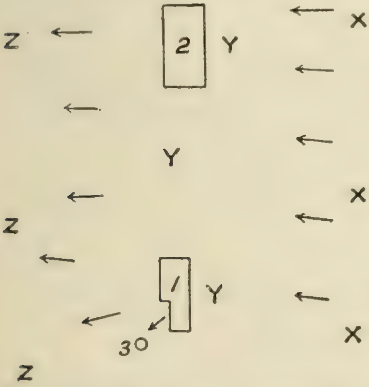

FIG. 11.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 11: 1, House; 2, barn; 3, well. X, High ground; Y, intermediate; Z, low ground.

Source of water supply.—(See fig. 11.) Well about 30 feet from the house; 10 feet in depth; no casing. *Strata:* Surface soil and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The mouth of the well is practically unprotected and can receive polluted surface drainage.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House and stables good; privy poor, unprotected vault.

Milk.—Used on farm; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 12. A polluted supply. It is very doubtful whether this supply could be made a safe one.

Location of farm.—Mankato, Minn.

Date of visit.—July 28, 1908.

Size.—One hundred and twenty acres.

Kind of farming.—Dairy and general.

Topography.—Low level ground in the Minnesota River Valley.

Source of water supply.—(See fig. 12.) Well at the side of the house porch; 25 feet in depth; casing, uncemented stone. *Strata:* Sand, clay, and gravel, more or less mixed. *Yield:* Abundant. *Use:* Drinking and house purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad; polluted from upper strata and also from surface wash. About July 1 the house cellar filled with surface water and the well water could not be used on account of its disagreeable taste and odor. Covering of well in good condition but on a level with surrounding ground.

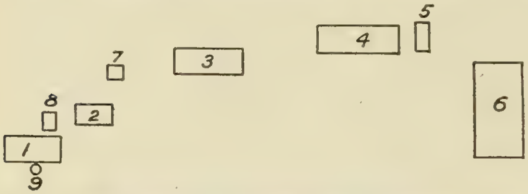

FIG. 12.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 12: 1, House; 2, ice house; 3, tool shed; 4, tool shed; 5, chicken house; 6, barn and basement stables; 7, privy; 8, milk house; 9, well.

Cisterns.—One, used for washing only.

Lakes, rivers, ponds, and springs.—Ponds during wet season. One spring, used for watering cattle.

Sanitary condition of farmhouse and outbuildings.—House very good; stables very good; milk house good; privy poor, open vault and unprotected.

Milk.—Retailed in city; sanitary care good.

Water-borne diseases.—One case of typhoid. A boy, aged 15 years, taken ill July 18; doctor called July 19 and pronounced the case typhoid; temperature 101°. This boy drank water in Mankato on July 5 and 12, which was during the course of a severe typhoid epidemic. From the dates of other cases in Mankato and from the fact that the trouble in that city is laid to the city water, which the boy drank, it is reasonable to assume this as the source of infection.

Analyses.—See page 78.

No. 13. A polluted supply. By proper grading and draining and by installing a good casing and tight covering this supply could be made safe.

Location of farm.—Mankato, Minn.

Date of visit.—July 28, 1908.

Size.—Twenty-eight acres.

Kind of farming.—Dairy.

Topography.—The surface surrounding the house and outbuildings is generally level, although several slight depressions hold surface water during the wet season.

Source of water supply.—(See fig. 13.). Well about 25 feet from house; 12 feet in depth; casing, uncemented stone. *Strata:* Blue clay, 8 feet, and gravel, 4 feet. *Yield:* During dry season supply is uncertain. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. Well receives surface wash from entire house and barnyard. Covering poor and allows back flow of water from pump. Privy, with old open vault, 25 feet from well. Pond polluted with algæ is located some 25 feet from the well and at about the same level.

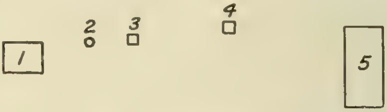

FIG. 13.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 13: 1, House; 2, well; 3, tool shed; 4, privy; 5, barn and stable.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Several ponds during wet season.

Sanitary condition of farmhouse and outbuildings.—House fair; stables very poor; privy poor.

Milk.—Retailed in city; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 14. A good supply, although it may become polluted by drainage from the upper strata.

Location of farm.—Mankato, Minn.
Date of visit.—July 28, 1908.
Size.—Sixty-five acres.
Kind of farming.—Dairy.
Topography.—House and outbuildings on level ground.
Source of water supply. (See fig. 14.) Well about midway between house and stables; 27 feet in depth; casing, uncemented stone. *Strata*: Surface soil and blue clay. *Yield*: Abundant except during a very dry season. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good, although well is too near barnyard. Mouth of well slightly raised and well covered.
Cisterns.—One, used only for washing.
Lakes, rivers, ponds, and springs.—Ponds during wet seasons.
Sanitary condition of farmhouse and outbuildings.—House good; stables good; milk house good; privy fair.
Milk.—Retailed in city of Mankato; sanitary care good.
Water-borne diseases.—None recorded.
Analyses.—See page 78.

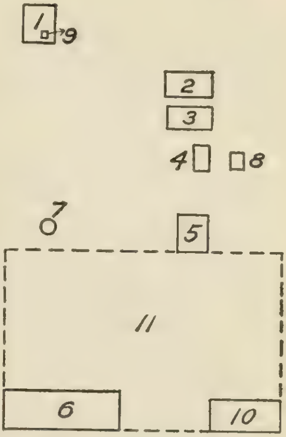

FIG. 14.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 14: 1, House; 2, smokehouse; 3, tool shop; 4, corncrib; 5, granary; 6, barn and stables; 7, well; 8, hogpen; 9, cistern; 10, barn and stables; 11, barnyard.

No. 15. The house supply is polluted, a condition which could be remedied by installing a good casing and a tight covering.

Location of farm.—Owatonna, Minn.
Date of visit.—July 30, 1908.
Size.—Two hundred acres.
Kind of farming.—Dairy and general.
Topography.—House and barn about 2 feet higher than intervening land.
Source of water supply.—(See fig. 15.) House supply (No. 2) under house porch; 40 feet in depth; casing, stone. *Strata:* Blue clay. *Yield:* Abundant. *Use:* Drinking and house purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Poor. The well receives surface wash at times of excessive rain. The open-vault privy is located some 40 feet away, which makes the location of the well more unsuitable. Stable supply (No. 9) near stables; 40 feet in depth; casing, wood. *Strata:* Sand, $15\frac{1}{2}$ feet, and blue clay, $24\frac{1}{2}$ feet. In this case a vein of water was found in the blue clay which is not characteristic for this locality. *Yield:* Abundant. *Use:* Farm purposes and at times for drinking. *Method of lifting:* Iron pump; windmill for power. *Sanitary aspect:* Fair; near the stables but reasonably well protected.
Cisterns.—One, used for washing.
Lakes, rivers, ponds, and springs.—None.
Sanitary condition of farmhouse and outbuildings.—House excellent; barn and stables excellent; privy poor.
Milk.—Sold to creamery; sanitary care excellent.
Water-borne diseases.—None recorded.
Analyses.—See page 78.

No. 16. A polluted supply. By draining the barnyard and outbuildings in another direction, which is possible in this case, and by installing a tight casing and covering this supply could be made satisfactory.

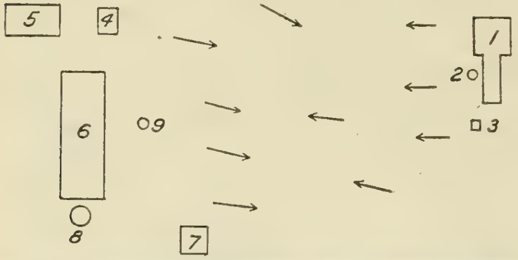

FIG. 15.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 15: 1, House; 2, well; 3, privy; 4, granary; 5, wagon shed; 6, barn and stables; 7, chicken house; 8, silo; 9, well.

Location of farm.—Owatonna, Minn.

Date of visit.—July 30, 1908.

Size.—One hundred and thirty-six acres.

Kind of farming.—General.

Topography.—Surface generally level, but barnyard slopes quite abruptly toward the well; about 8 feet difference in elevation between well and surrounding higher ground.

Source of water supply.—(See fig. 16.) Well in barnyard about 35 feet from stables; 30 feet in depth; casing, uncemented stone. *Strata:* Unknown; judging from other wells in locality, blue clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump; windmill used for power. *Sanitary aspect:* Very bad. The entire drainage of the barnyard flows toward the well; puddles surround the well; the mouth is slightly raised but at times surface wash enters.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables and barnyard poor; privy very poor, open vault.

Milk.—Sold to creamery; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

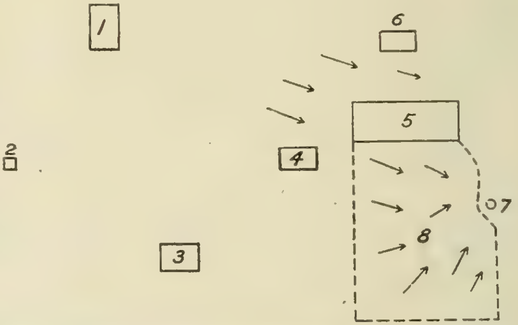

FIG. 16.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 16: 1, House; 2, privy; 3, granary; 4, tool shed; 5, barn and stables; 6, corncrib; 7, well; 8, barnyard.

No. 17. A polluted supply. This supply could be made satisfactory by installing a good casing and a tight covering and by trenching and banking the soil around the mouth of the well to turn the flow of surface water in the opposite direction.

Location of farm.—Austin, Minn.

Date of visit.—August 1, 1908.

Size.—Six hundred and forty acres.

Kind of farming.—General.

Topography.—Surface level around house and outbuildings.

Source of water supply.—(See fig. 17.) Well very near stables and surrounded by farm buildings; 60 feet in depth; casing, tile. *Strata:* Yellow clay. *Yield:* Abundant.

Use: Drinking and general farm purposes. *Method of lifting:* Iron pump; windmill for power. *Sanitary aspect:* Bad. During heavy rains so much surface water enters that well can not be used for several days.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House excellent; stables good; milk-house fair; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care good.

Water-borne diseases.—None recorded..

Analyses.—See page 78.

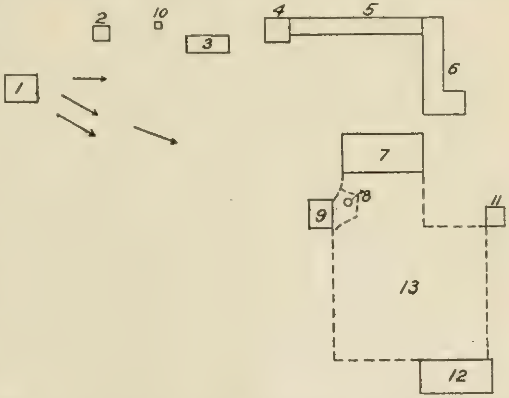

Fig. 17.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 17: 1, House; 2, wood shed; 3, corncrib; 4, granary; 5, wagon shed; 6, chicken house; 7, barn and stables; 8, well; 9, ice house; 10, privy; 11, tool shed; 12, stables; 13, barnyard.

No. 18. A polluted supply. This well could unquestionably be made a safe supply by improving the construction of the casing and covering.

Location of farm.—Austin, Minn.

Date of visit.—August 1, 1908.

Size.—Eighty acres.

Kind of farming.—General.

Topography.—House about 2½ feet above stables; well on same level as house.

Source of water supply.—(See fig. 18.) Well about halfway between house and stables; 28 feet in depth; 3 feet square; casing, wood. *Strata:* Surface soil, 2 feet; sand, 8 feet; hardpan, 4 feet; sand, 6 feet, and rock, 8 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Surface covered with loose boards; surface water at times undoubtedly enters; surface drainage away from well except during heavy rains.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stable very poor; privy very poor, open vault, very poorly protected and shows no attention whatever.

Milk.—Made into butter; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

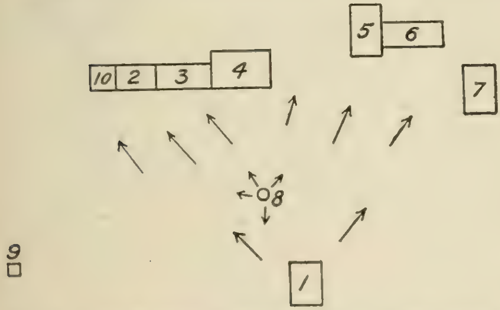

Fig. 18.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 18: 1, House; 2, milk house; 3, cow stable; 4, barn and stables; 5, corncrib; 6, hogpen; 7, granary; 8, well; 9, privy; 10, wood shed.

No. 19. A polluted supply. The polluting environment should be removed or a well dug in a better location. In either case a proper covering and a good pump should be installed.

Location of farm.—Oakland, Minn.

Date of visit.—August 1, 1908.

Size.—Seventy acres.

Kind of farming.—General.

Topography.—The surface surrounding house has been artificially raised about 1 foot above outbuildings; well is on same level as stables and barnyard.

Source of water supply.—(See fig. 19.) Well several feet from barnyard and stables; 12 feet in depth; casing, 2-foot tile. *Strata:* Black loam, 2 feet; gravel, blue clay, and quicksand at bottom. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Wooden pump. *Sanitary aspect:* Bad, due to the filthy barnyard about 10 feet away. Surface wash is prevented by a 1-foot extension of tile.

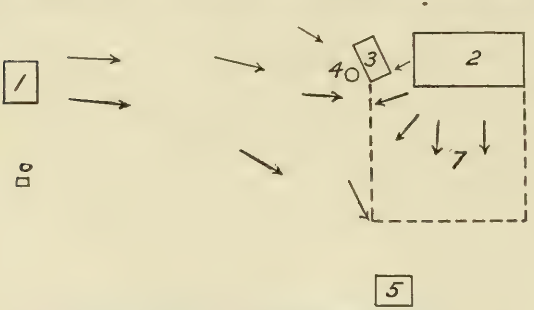

FIG. 19.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 19: 1, House; 2, stable and barn; 3, tool shed; 4, well; 5, wagon shed; 6, privy; 7, barnyard.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor; privy very poor, uncared for, open vault.

Milk.—Sold to creamery; sanitary care very poor.

Water-borne diseases.—One case of typhoid in October, 1901; several cases were in the neighborhood about the same time.

Analyses.—See page 78.

No. 20. A polluted supply. It is probable that even the best protection in the way of construction would not preserve the purity of this supply. One should be secured in a better location.

Location of farm.—Oakland, Minn.

Date of visit.—August 1, 1908.

Size.—Two hundred and thirty-five acres.

Kind of farming.—General.

Topography.—Elevation of ground between house and outbuildings about 1½ feet, with a very gradual slope toward house and stables.

Source of water supply.—(See fig. 20.) Well partly under doorstep of house; 30 feet in depth; casing, cemented stone. *Strata:* Surface soil, 3 feet; remainder clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The house cellar, about 4 feet distant, contained 2 feet of water. Well water has peculiar taste whenever cellar fills, showing that there is chance of pollution from upper strata. This well is undoubtedly dangerous during wet seasons.

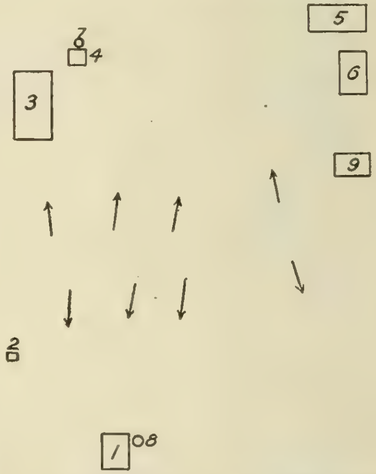

FIG. 20.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 20: 1, House; 2, privy; 3, barn and stables; 4, tool shed; 5, storehouse and corncrib; 6, granary; 7, cattle well; 8, well; 9, old log house.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good with exception of cellar, which contained water which as fast as pumped out flows in from surrounding saturated earth; stables very good; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 21. A good supply. This supply could be improved by installing a tight casing.

Location of farm.—Rochester, Minn.

Date of visit.—August 4, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—General.

Topography.—The ground slopes from the house in the direction of the stables, which are about 7 feet lower.

Source of water supply.—(See fig. 21.) Well about 25 feet from house, 50 feet from stables; 30 feet in depth; casing, uncemented stone. *Strata:* Surface soil, 3 feet; clay, 10 feet; gravel, 17 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good. Mouth of well protected with tight board cover. Privy about 50 feet from well on same level, but vault is well protected.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House and stables excellent; privy good, tightly boxed vault, well protected.

Milk.—Sold to dealer; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

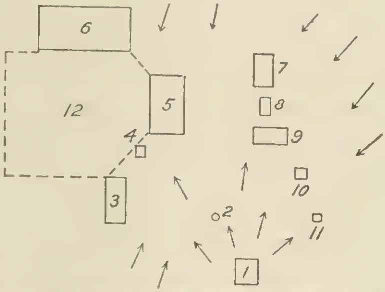

FIG. 21.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 21: 1, House; 2, well; 3, hogpen; 4, stable well and pump house; 5, stable; 6, barn and stables; 7, granary; 8, corncrib; 9, tool shed; 10, smokehouse; 11, privy; 12, barnyard.

No. 22. A polluted supply. A safe supply could be secured by proper drainage and by improving the casing and covering.

Location of farm.—South Haven, Minn.

Date of visit.—August 14, 1908.

Size.—One hundred and fifty acres.

Kind of farming.—General.

Topography.—The stables and house are on the same level; the well is about 2 feet below. The surface flow from outbuildings and barnyard is partly in the direction of the well.

Source of water supply.—(See fig. 22.) Well about 20 feet from house; 14 feet in depth; casing, 1½-inch wooden planks. *Strata:* Clay, 13 feet, and gravel and sand, 1 foot. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. Surface drainage from house and outbuildings enters in case of heavy rains. Mouth of well is poorly covered with rough boards.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—A stagnant pond lies about 50 feet away, but at a much lower level; another stagnant pond is located about 200 feet in opposite direction from well.

Sanitary conditions of farmhouse and outbuildings.—House and stables poor; privy very poor, open vault, unprotected and shows entire lack of care.

Milk.—Entire supply made into butter; sanitary care very poor.

Water-borne diseases.—One case of typhoid fever, a young woman 20 years old, occurred on the place during the early spring of 1908. She had made several visits to neighbors, but no record of any cases could be found among the people she visited. It is impossible with the data at hand to locate the source of infection.

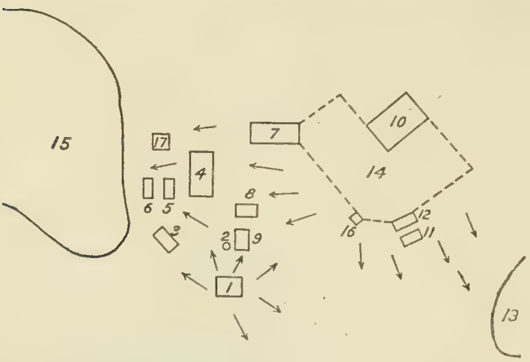

FIG. 22.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 22: 1, House; 2, well; 3, tool shed; 4, granary; 5, corncrib; 6, corncrib; 7, wagon shed; 8, smokehouse; 9, tool shed; 10, stables; 11, chicken house; 12, corncrib; 13, pond; 14, barnyard; 15, pond; 16, privy; 17, hogpen.

Analyses.—See page 78.

No. 23. A polluted supply. This supply if protected could be improved, but probably could not be made safe.

Location of farm.—St. Cloud, Minn.

Date of visit.—August 14, 1908.

Size.—Two hundred and forty-eight acres.

Kind of farming.—General.

Topography.—The ground surrounding the farmhouse and outbuildings is very level.

Source of water supply.—(See fig. 23.) Well about 26 feet from house; 44 feet in depth; casing, brick. *Strata:* Clay, hardpan, gravel, and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect*: Bad. The mouth of the well is poorly covered with rough boards and receives surface wash.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables poor; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care very poor.

Water-borne diseases.—One case of typhoid on this place some eighteen years previous to visit.

Analyses.—See page 78.

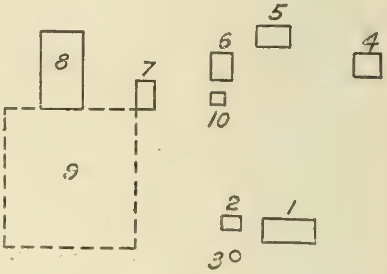

FIG. 23.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 23: 1, House; 2, smokehouse; 3, well; 4, granary; 5, chicken house; 6, corncrib; 7, corncrib; 8, barn and stables; 9, barnyard; 10, privy.

No. 24. A polluted supply. This supply could be made very satisfactory by installing a good casing and tight covering.

Location of farm.—Sauk Center, Minn.

Date of visit.—August 17, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Ground surrounding house and outbuildings is quite level. Well is located on same level as stables, but 1 foot below level of house.

Source of water supply.—(See fig. 24.) Well about 70 feet from house; 25 feet in depth; 3 feet square; casing, wood. *Strata:* Clay and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Wooden pump. *Sanitary aspect:* Bad. Surface wash and back flow from pump enter freely. Large fungous growths project from the sides of well at surface of water. Well is used for cooling milk and other articles of food.

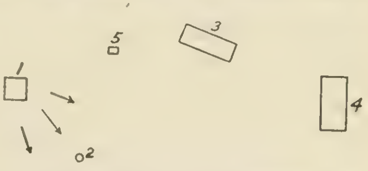

FIG. 24.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 24: 1, House; 2, well; 3, tool shed; 4, stable; 5, privy.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables poor; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care very poor.

Water-borne diseases.—One case of typhoid, a farm hand, appeared on this place August 7, 1908. The patient had not used water from any other source for over a month. This being the busy harvest season, the man had been confined closely to work for over a month and recalled no trips away from home except a visit now and then to near neighbors. At that time no other cases were present in the immediate vicinity. One case of typhoid was located some 3 miles from this farm, but no communication whatever could be traced from this source to the patient or to any of the near neighbors. The patient lays the source of his infection to the well, but although the sanitary surroundings of the well are bad, it would be impossible to fix this as the infecting agent without more definite information.

Analyses.—See page 78.

No. 25. A polluted supply. This supply could be made safe by installing a good casing and adding the necessary surface protections.

Location of farm.—Crookston, Minn.

Date of visit.—September 10, 1908.

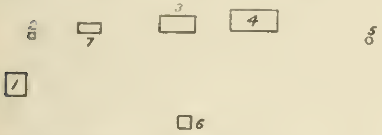

FIG. 25.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 25: 1, House; 2, privy; 3, granary; 4, stables; 5, well; 6, tool shed; 7, chicken coop.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Level prairie; no natural slopes drain the surface in any direction.

Source of water supply.—(See fig. 25.) Well about 50 feet from stable; 40 feet in depth; 3 feet square; casing, boards. *Strata:* Blue clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Wooden pump. *Sanitary aspect:* Bad. The covering admits both surface wash from barnyard and back flow from pump; casing broken in many places. Pieces of wood, fungous growths, and other decomposing organic materials were floating on surface of water.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None permanent.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor; privy poor, open vault with very little protection.

Milk.—Made into butter and sold in Crookston; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 26. A polluted supply. As there are many other much more favorable locations within a few rods, it would be better to relocate than to attempt to improve the structure materially.

Location of farm.—Huot, Minn.

Date of visit.—September 11, 1908.

Size.—Two acres.

Kind of farming.—General.

Topography.—House and outbuildings located on level land with a very gradual slope in the direction of the river and also away from the river. House about 25 feet above Red Lake River. The slope right at river bank is very abrupt.

Source of water supply.—(See fig. 26.) Well about 20 feet from river and 10 feet above river bed; 12 feet in depth; casing, boards. *Strata:* Sand, gravel, and clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. Surface wash from steep bank above flows directly into well. On date of visit well contained all sorts of organic material, both living and dead. The pump being out of order, a pail and rope were used. The first pail drawn contained two frogs, numerous bugs, sticks, grass, and considerable mud. The people on the farm continue to drink the water.

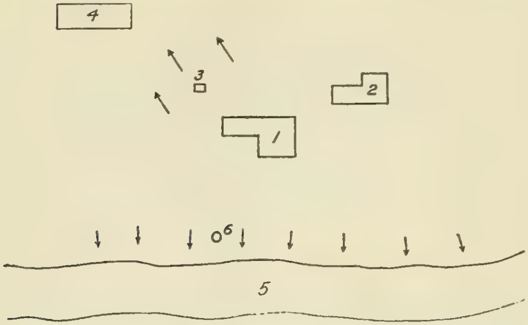

FIG. 26.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 26: 1, House and general store; 2, stables; 3, privy; 4, beehouse; 5, Red Lake River; 6, well.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Red Lake River flows by edge of farm. The river water is used for drinking purposes during the winter season.

Sanitary condition of farmhouse and outbuildings.—House good; stables fair; privy poor, open vault and unprotected.

Milk.—Buy milk from creamery.

Water-borne diseases.—One case of typhoid occurred on this farm during the spring of 1908. A man, aged 38, was taken ill April 1. The patient had been at home for some time previous to the infection and had taken care of his brother, who contracted the disease February 28. He drank water from the river entirely from November 15 to date of illness. This case may be one of infection from the river water or by contact in caring for his brother during his illness.

Analyses.—See page 78.

No. 27. A polluted supply. This supply could be very much improved by installing a good casing, by banking the surface to carry away surface water, and by the installation of a pump.

Location of farm.—Thief River Falls, Minn.

Date of visit.—September 14, 1908.

Size.—One hundred and forty-five acres.

Kind of farming.—Grain.

Topography.—Surface on which farm buildings are located is level prairie land.

Source of water supply.—(See fig. 27.) Well about 20 feet from house; 13 feet in depth; 3 feet square; casing, boards. *Strata:* Blue clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Rope and tin bucket. *Sanitary aspect:* Bad. Well receives surface wash from all directions; mouth surrounded with decomposing straw. The well is used to cool food products, and just before date of visit a can of milk had been spilled into it; odor and appearance of water very bad. The utensils used in drawing water were very dirty.

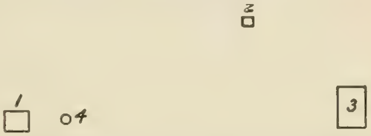

FIG. 27.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 27: 1, House; 2, privy; 3, stable; 4, well.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables fair; privy poor, open vault and unprotected. This is really a primitive farm and has been occupied only three years.

Milk.—Made into butter and sold in Thief River Falls; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 28. A polluted supply. This supply could be improved by completing the casing and making a tight cover.

Location of farm.—Hallock, Minn.

Date of visit.—September 16, 1908.

Size.—Three hundred and twenty acres.

Kind of farming.—General.

Topography.—Buildings are on level prairie. Drainage from farm buildings by artificial means reaches the Middle Branch River.

Source of water supply.—(See fig. 28.) Well about 40 feet northeast of house; 18 feet in depth; casing, 10 feet brick and 8 feet boards. *Strata:* Surface loam, 2 feet; yellow clay, 5 feet; gravel, sand, and clay, 6 feet; hardpan, 5 feet. *Yield:* Insufficient during months of March and April. *Use:* Drinking and general farm purposes. *Method of lifting:* Rope and bucket. *Sanitary aspect:* Bad. Mouth of well covered with loose boards; surface wash enters freely.

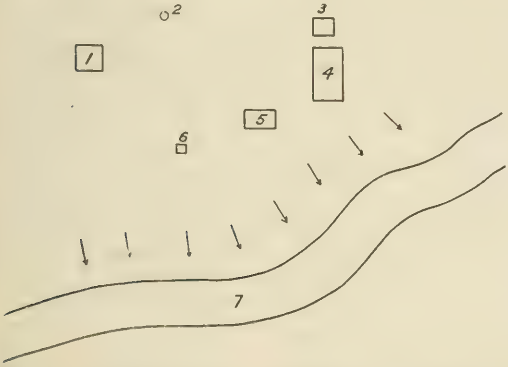

FIG. 28.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 28: 1, House; 2, well; 3, granary; 4, stables; 5, tool shed; 6, privy; 7, Middle Branch River.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Middle Branch River flows near house.

Sanitary condition of farmhouse and outbuildings.—House poor; stables fair; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

BORED WELLS.

No. 1. A polluted supply. This supply could be made safe by installing a tight casing and good covering.

Location of farm.—Chikio, Minn.
Date of visit.—August 10, 1908.
Size.—One hundred and sixty acres.
Kind of farming.—General.
Topography.—The ground on which the house and outbuildings are located is level.

Source of water supply.—(See fig. 29.) Well about 50 feet from stables and at corner of barnyard; 55 feet in depth; casing, board, 1½ feet in diameter. *Strata:* Clay, 40 feet; sand and gravel, 15 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair; too near barnyard. Mouth of well is raised 2½ feet above surrounding surface; board covering in poor repair.

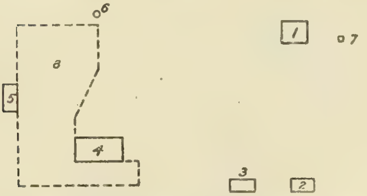

FIG. 29.—Sketch showing the topography and the location of buildings in the vicinity of bored well No. 1: 1, House; 2, granary; 3, tool shed; 4, barn and stables; 5, hogpen; 6, well; 7, privy; 8, barnyard.

Cisterns.—None.
Lakes, rivers, ponds, and springs.—None.
Sanitary condition of farmhouse and outbuildings.—House fair; stables good; privy very poor, open vault and unprotected.
Milk.—Sold to butter factory; sanitary care fair.
Water-borne diseases.—One case of typhoid, July 15, 1908. The patient, a hired man, had not visited Morris or any of the surrounding villages for some time previous to infection, which could not be traced. No other people on the farm became infected.
Analyses.—See page 78.

No. 2. A polluted supply. The installation of a good casing and the proper draining or the removal of the barnyard would make this a satisfactory supply.

Location of farm.—Sauk Center, Minn.
Date of visit.—August 17, 1908.
Size.—One hundred and twenty acres.
Kind of farming.—General.
Topography.—Surface adjacent to farm buildings quite level. The house, however, is elevated about 1 foot above the level of the well; drainage from the house would be in the direction of the well and stables.

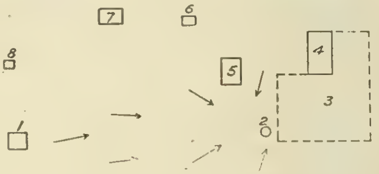

FIG. 30.—Sketch showing the topography and the location of buildings in the vicinity of bored well No. 2: 1, House; 2, well; 3, barnyard; 4, barn and stables; 5, granary; 6, tool shed; 7, chicken house; 8, privy.

Source of water supply.—(See fig. 30.) Well several feet from barnyard; 27 feet in depth; no casing. *Strata:* Clay and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Wooden pump. *Sanitary aspect:* Bad. Location near barnyard and on same level makes contamination from that source possible. Surface wash and back flow from pump enters well freely. Occasionally water has a bad taste, which is probably due to wash from barnyard.
Cisterns.—None.
Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables poor; privy very poor, open vault and entirely unprotected.

Milk.—Cream sold to creamery; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 3. A badly polluted supply. This supply could be rendered fit for use by installing a pump and protecting the well from surface pollution.

Location of farm.—Argyle, Minn.

Date of visit.—September 12, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Surface surrounding buildings about 12 feet above the bed of Snake River; very level with the exception of an abrupt fall 50 feet from the house toward the river.

Source of water supply.—(See fig. 31.) Well about 30 feet from house; 10 feet in depth; casing, 6-inch tin pipe. *Stratum:* Blue prairie clay. *Yield:* Abundant except during dry season. *Use:* Drinking and general farm purposes. *Method of lifting:* Tin bucket with a loose bottom. *Sanitary aspect:* Very bad. One bucket of water contained frogs, bugs, sticks, straw, and mud. The covering of the well consists of the top of a milk can, which evidently is used only when the water becomes unusually filthy.

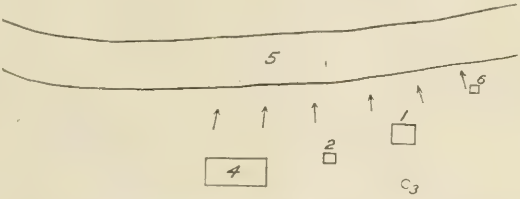

FIG. 31.—Sketch showing the topography and the location of buildings in the vicinity of bored well No. 3: 1, House; 2, tool shed; 3, well; 4, stables; 5, Snake River; 6, privy.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—One river.

Sanitary condition of farmhouse and outbuildings.—House very poor, a disgusting odor making it almost impossible to remain inside; stable very poor; privy very poor, open vault and entirely unprotected.

Milk.—The entire supply is used by the family; sanitary care very poor, all utensils filthy.

Water-borne diseases.—Six cases of typhoid fever occurred in this family during the spring months of 1908: A girl, age 18 years, taken ill March 25; a boy, 12 years, April 15; a boy, 8 years, May 26; a girl, 15 years, May 30; a woman, 41 years, May 31; a boy, 18 years, June 1. The original case of this infection was brought from Oslo, Minn., where the girl had been employed in a hotel as a servant. The other cases were probably infected by contact, although the well, also, might have been a means of carrying the infection.

Analyses.—See page 78.

No. 4. A badly polluted supply. The sanitary condition of this supply could be improved by proper surface protection, and by installing a good pump the water could be made safe as long as the tin casing remained in good condition.

Location of farm.—Argyle, Minn.

Date of visit.—September 12, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Surface surrounding farm buildings is level prairie.

Source of water supply.—(See fig. 32.) Well about 50 feet south of house; 13 feet in depth; casing, 6-inch tin pipe. *Strata:* Blue clay. *Yield:* Abundant. *Use:* Drinking and general house purposes. *Method of lifting:* Rope and tin bucket. *Sanitary aspect:* Poor. This well is so situated that it receives surface wash whenever precipitation is sufficient to cover the surface. No covering is used for protection, so the water necessarily receives considerable surface dust and organic pollution.

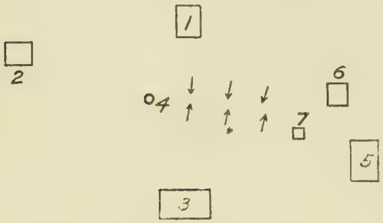

Fig. 32.—Sketch showing the topography and the location of buildings in the vicinity of bored well No. 4· 1, House; 2, granary; 3, stables; 4, well; 5, chicken house; 6, tool shed; 7, privy.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables good; privy has open vault and is unprotected.

Milk.—Used on farm; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 5. Probably a good supply. The supply should be farther from the outbuildings.[a]

Location of farm.—Minneapolis, Minn.

Date of visit.—December, 1908.

Size.—Two acres.

Kind of farming.—General.

Topography.—Land slopes gently toward a marsh which borders Maxwell Bay; house and outbuildings near edge of marsh.

Source of water supply.—(See fig. 33.) Well near house and barn; 21 feet in depth; casing, 6-inch tile. *Strata:* Few inches black earth; 20 feet hard bluish clay; water-bearing stratum, quicksand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; barn poor.

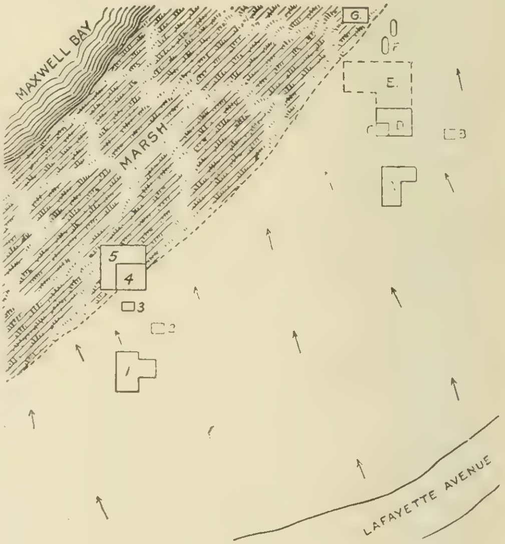

Fig. 33.—Sketch showing the topography and the location of buildings in the vicinity of bored wells Nos. 5 and 6: A, House of farm No. 5; B, well; C, privy; D, barn and wood shed; E, chicken yard; F, haystacks; G, ice house. 1, House of farm No. 6; 2, well; 3, privy; 4, horse and cow stables; 5, chicken yard.

Milk.—Occasionally supplied summer residents in the neighborhood; sanitary care poor.

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[a] Data for this report furnished by Dr. H. W. Hill, of the Minnesota State Board of Health.

Water-borne diseases.—Two cases of typhoid fever, the first, a man 32 years old, taken sick September 11, 1908, and the second, a girl 10 years old, taken sick October 20. Source of infection for first case, Minneapolis; for second, contact or infected milk.

Analyses.—See page 78.

No. 6. Probably a good supply. The supply should be farther from the outbuildings.[a]

Location of farm.—Minneapolis, Minn.

Date of visit.—December, 1908.

Size.—Two acres.

Kind of farming.—General.

Topography.—Land slopes gently toward a marsh which borders Maxwell Bay; house and outbuildings near edge of marsh.

Source of water supply.—(See fig. 33.) Well near house, privy, and stables; 21 feet in depth; casing, 6-inch tile. *Strata:* Few inches black earth, 20 feet hard bluish clay; water-bearing stratum, quicksand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stable poor.

Milk.—Obtained from neighbor three-fourths mile away, except about 5 quarts, taken at different times, from next door (see No. 5, fig. 33).

Water-borne diseases.—Two cases of typhoid fever; first, a girl 15 years old, taken sick October 13, 1908; second, a boy 10 years old, taken sick October 18. Source of infection, milk or contact.

Analyses.—See page 78.

DRILLED WELLS.

No. 1. A polluted supply. The pollution may be due to surface water following the iron pipe to the point where it touches the rock and possibly gaining entrance there, but is more probably due to leaks in the cistern holding well water a short distance away. Both well and cistern should be protected from surface wash and seepage from the upper strata.

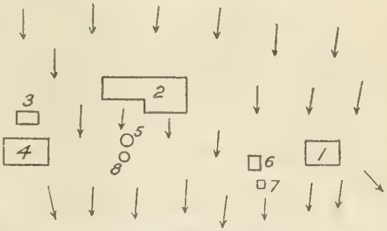

FIG. 34. Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 1: 1, House; 2, stables; 3, corncrib; 4, hay shed; 5, well; 6, chicken house; 7, privy; 8, cistern (well).

Location of farm.—Red Wing, Minn.

Date of visit.—July 24, 1908.

Size.—Eighteen acres.

Kind of farming.—Dairy.

Topography.—All the buildings are on a steep incline.

Source of water supply.—(See fig. 34.) Well in barnyard; 138 feet in depth; casing, 6-inch iron pipe to a depth of 17 feet, remainder rock. *Strata:* Clay, 17 feet; remainder limestone rock. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, horse sweep used for power. *Sanitary aspect:* Fair. Well in center of barnyard below level of stable. Casing attached to pump.

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[a] Data for this report furnished by Dr. H. W. Hill, of the Minnesota State Board of Health.

Cisterns.—Two. A cement cistern used to hold surplus supply for cattle is located in barnyard near pump. This cistern is evidently very badly polluted, as the water is discolored and has a very unpleasant odor. The house cistern is used for washing purposes and for cooling milk.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stables poor; privy poor, unprotected vault.

Milk.—Retailed in Red Wing; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 2. A badly polluted supply. The practice of using an unprotected dug well as a surface reservoir is undesirable, to say the least. It is an open question whether this supply is responsible for the three typhoid fever cases on the farm.

Location of farm.—St. Peter, Minn.

Date of visit.—July 27, 1908.

Size.—One hundred and twenty acres.

Kind of farming.—General.

Topography.—The ground immediately surrounding the house has been artificially raised about 6 inches to turn surface wash.

Source of water supply.—(See fig. 35.) Well about 35 feet from house; 167 feet in depth, dug 25 feet and drilled 142 feet; casing, 2-inch iron pipe; well pit, 25 feet deep, cased with uncemented stone. *Strata:* Surface soil and clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Very bad. The well pit is used as a supply tank, the water being pumped out of the deep well by a windmill into the well pit. The mouth of the pit is very poorly protected with loose boards, which are lower than surrounding surface. During heavy rains water runs freely into well pit, and the privy, which is 75 feet away, undoubtedly contributes to the surface wash which finally reaches the well pit.

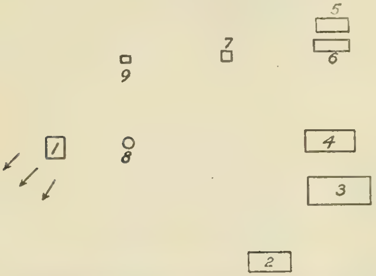

FIG. 35.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 2: 1, House; 2, granary; 3, stables; 4, chicken house; 5, corncrib; 6, corncrib; 7, smokehouse; 8, well; 9, privy.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—Shallow puddles during wet season, no permanent ponds.

Sanitary condition of farmhouse and outbuildings.—House good; barn fair; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care fair.

Water-borne diseases.—Three positive cases of typhoid fever, a man and a woman taken sick July 7, 1908, and a woman taken sick July 17. The history of these cases shows visits to St. Peter; only one of these patients drank city water, however, and she was taken sick three days later, which allows too short a period for the incubation of the disease. No other cases of typhoid have been reported recently among the users of city water. No other cases have been reported in the rural districts in that vicinity, nor have any of the patients visited homes or associated with people known to have typhoid. All the patients were users of the farm water supply.

Analyses.—See page 78.

No. 3. A polluted supply. Extra precautions should be taken in the case of this well to cover the casing properly and avoid the inflow of back wash from the pump, which at times may cause a serious pollution.

Location of farm.—Owatonna, Minn.

Date of visit.—July 30, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—General.

Topography.—Gradual slope from the house toward the stables; difference in elevation between house and stables about 2½ feet.

Source of water supply.—(See fig. 36.) Two wells (No. 3 and No. 10). Well No. 3, near stables, 107 feet in depth; casing, 6-inch iron pipe. *Strata:* Blue clay and small quantity of rock. *Yield:* Abundant. *Use:* For cattle only. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair. This well is quite near stables and barnyard, but its depth and especially good surface protection will undoubtedly keep it free from pollution. Well No. 10, about 50 feet from house, 100 feet in depth, dug 40 feet and drilled 60 feet; casing, stone in dug portion, 6-inch iron pipe in drilled portion. *Strata:* Blue clay and 10 feet of rock at bottom. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Except in cases of heavy rains there is little opportunity for surface wash.

Cisterns.—One, used for drinking water.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stables fair; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care fair.

Water-borne diseases.—One case of typhoid, taken sick April 11, 1908. The patient claims to have drunk no water except from well No. 10. In one other case of typhoid, about a mile and a half from this farm, the patient had just recovered. Neither patient admits having visited the other at any time previous to infection.

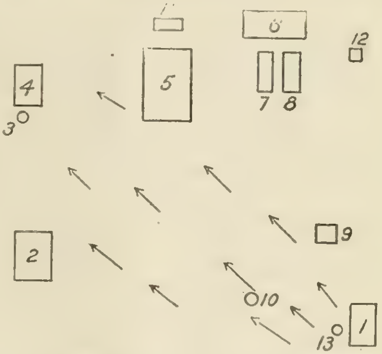

FIG. 36.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 3: 1, House; 2, stables; 3, well; 4, stables; 5, granary; 6, henhouse; 7, corncrib; 8, corncrib; 9, smokehouse; 10, well; 11, hogpen; 12, privy; 13, cistern.

Analyses.—See page 78.

No. 4. A polluted supply. This supply offers good opportunity for occasional serious pollution due to improper construction. The sanitary condition of the water could undoubtedly be improved by extending the casing to the base of the pump, by properly protecting the well pit, or by covering the mouth of the casing with a tight cover.

Location of farm.—Owatonna, Minn.

Date of visit.—July 30, 1908.

Size.—Two hundred and forty acres.

Kind of farming.—General.

Topography.—Difference in elevation between house and granary about 8 feet; well located on level with house and stables.

Source of water supply.—(See fig. 37.) Well near corner of barn; 90 feet in depth; casing, 6-inch iron pipe; well pit 10 feet deep, cased with boards. *Strata:* Clay, 40 feet; remainder gravel and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Bad. Very near stables and surface wash sometimes fills the well pit. The iron casing does not extend to the pump, so when the pit is full this surface water may enter the well directly.

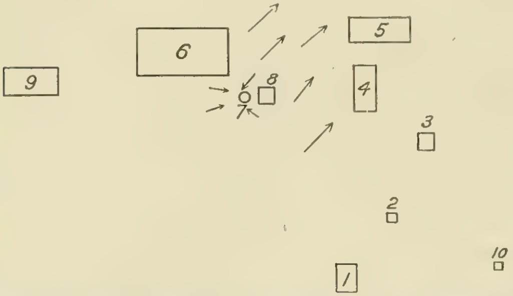

FIG. 37.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 4: 1, House; 2, wood shed; 3, smokehouse; 4, chicken house; 5, granary; 6, barn and stables; 7, well; 8, milk house; 9, hogpen; 10, privy.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables good; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care fair.

Water-borne diseases. — One case of typhoid, a man, taken sick October 12, 1908. No other cases were known to be in the neighborhood at that time. Patient previously had visited a great many farms with a thrashing crew.

Analyses.—See page 78.

No. 5. A polluted supply. This pollution is due chiefly to inflow of water from the dug portion directly into the deep well casing. The water could be greatly improved by extending the casing, then filling part of the dug portion—say, to within 10 feet of the surface and using this as a well pit—and carefully installing means of excluding surface pollution.

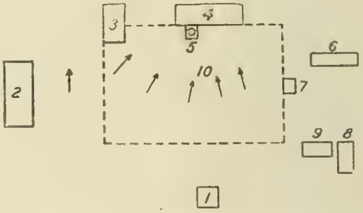

FIG. 38.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 5: 1, House; 2, barn and stables; 3, stables; 4, stables; 5, well and milk house; 6, chicken house; 7, granary; 8, wood and wagon shed; 9, tool shed; 10, barnyard.

Location of farm.—Rochester, Minn.

Date of visit.—August 4, 1908.

Size.—One hundred and eighty-five acres.

Kind of farming.—General.

Topography.—Difference in elevation between house and stables about 3 feet; slope from house toward stables; stables on same level as well.

Source of water supply.—(See fig. 38.) Well in barnyard near stables; 60 feet in depth, dug 30 feet and drilled 30 feet; casing, dug portion uncemented stone, drilled portion 3-inch iron casing. *Strata:* Sand and clay, 30 feet; remainder limestone. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Bad. Mouth of well covered with loose boards. Surface immediately around well has been raised, but not enough to prevent surface wash into dug portion during heavy rains. Water from dug portion is said to flow into the casing of drilled portion at times.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables very poor; milk house very poor; privy poor, unprotected vault.

Milk.—Cream sold to butter factory; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 6. A polluted supply. The protection of this well is apparently good, yet the water is evidently polluted. The bad location of the well and the poor protection of the mouth of the well may be responsible for this pollution. It is also possible that pollution is drawn from some underground source, as the well and the lake have about the same level.

Location of farm.—Alexandria, Minn.

Date of visit.—August 12, 1908.

Size.—One hundred and forty-one acres.

Kind of farming.—General.

Topography.—A small creek separates house from most of the outbuildings. The depression formed by creek is very narrow, but about 6 feet deep. Lake Andrews is located about 40 rods from house and at a level 15 or 20 feet lower.

Source of water supply.—(See fig. 39.) Well about 25 feet from house; 80 feet in depth; casing, 3-inch iron pipe attached to base of pump. *Strata:* Gravel, 10 feet; few feet red clay; 50 feet blue clay; and 10 feet of sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Mouth of well several feet below level of house and of surrounding ground; covering very poor.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Lake Andrews 40 rods away; flowing spring near stables; small creek leading from spring to lake.

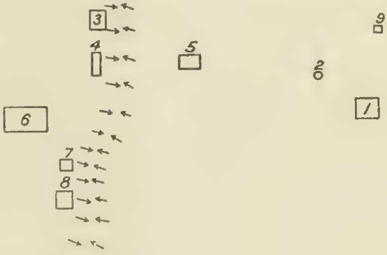

FIG. 39.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 6: 1, House; 2, well; 3, hogpen; 4, corncrib; 5, chicken coop; 6, barn and stables; 7, granary; 8, tool shed; 9, privy.

Sanitary condition of farmhouse and outbuildings.—House fair; stables fair; privy poor, open vault and unprotected.

Milk.—Cream sold to butter factory; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 7. A polluted supply. The location of the well is bad, yet with good surface protection the supply might be made safe.

Location of farm.—Alexandria, Minn.

Date of visit.—August 12, 1908.

Size.—Two hundred and twenty acres.

Kind of farming.—General.

Topography.—The house is elevated slightly above level of stables; other outbuildings on same level with house. The surface slopes very abruptly from stables on side away from house. Drainage from stables and barnyard empties into a pond about 8 rods distant.

Source of water supply.—(See fig. 40.) Well about 15 feet from house; 60 feet in depth; casing, iron pipe. *Strata:* Clay and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad; too near privy. Covering in poor condition; waste water from pump sinks into ground around the casing.

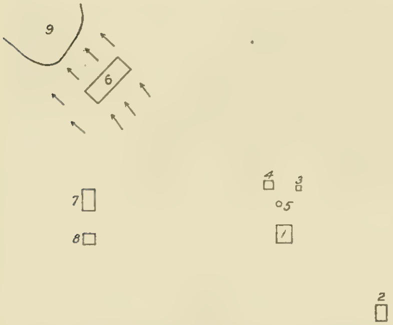

FIG. 40.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 7: 1, House; 2, ice house; 3, privy; 4, outdoor kitchen; 5, well; 6, barn and stable; 7, wagon shed; 8, granary; 9, pond.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—Several ponds.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables fair; privy poor, open vault and unprotected.

Milk.—Cream sold to creamery; sanitary care very poor.

Water-borne diseases.—About one year previous to date of visit an infection of typhoid occurred on this farm and gave rise to eight cases of typhoid. The attending physician lays the source to a shallow well then in use by the family, which has since been filled.

Analyses.—See page 78.

No. 8. A good supply. If the well pit was tightly cased it would give greater protection against back wash from the pump and inflow from the upper strata.

Location of farm.—Sauk Center, Minn.

Date of visit.—August 17, 1908.

Size.—Three hundred and thirty acres.

Kind of farming.—General.

Topography.—The house is about 2 feet above granary and well and about 4 feet above barn.

Source of water supply.—(See fig. 41.) Well about 40 feet from house; 153 feet in depth; casing, 4-inch iron pipe; well pit about 3 feet square, 10 feet deep, cased with boards. *Strata:* Yellow clay, 30 feet; hardpan, 12 feet; sand, 15 feet; clay, 90 feet; and about 5 feet of sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Good. Mouth of well protected by tight covering. A small quantity of back flow enters well pit as drainage from pump cylinder.

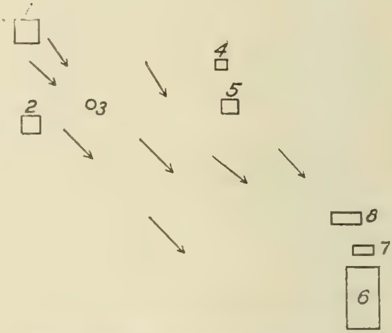

FIG. 41.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 8: 1, House; 2, granary; 3, well; 4, privy; 5, ice house; 6, barn and stables; 7, corncrib; 8, hogpen.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables fair; privy poor, open vault and unprotected.

Milk.—Cream sold to creamery; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 9. A good supply.

Location of farm.—Crookston, Minn.
Date of visit.—September 10, 1908.
Size.—Two hundred and forty acres.
Kind of farming.—Grain.
Topography.—Level prairie.
Source of water supply.—(See fig. 42.) Well in combination ice and pump house; 200 feet in depth; casing, 2-inch iron pipe. *Strata:* Blue clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Good. A double board covering protects the 10-foot well pit from surface wash and back flow, and casing extends to base of pump. More than the usual precautions are observed in protecting this well.
Cisterns.—One, used for washing.
Lakes, rivers, ponds, and springs.—None.
Sanitary condition of farmhouse and outbuildings.—House good; stables fair; privy has open vault, slightly protected.
Milk.—Sold in Crookston; sanitary care fair.
Water-borne diseases.—None recorded.
Analyses.—See page 78.

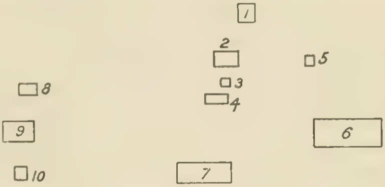

FIG. 42.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 9: 1, House; 2, woodshed; 3, privy; 4, chicken house; 5, well and ice house; 6, stables; 7, machine shed; 8, chicken coop; 9, machine shed; 10, hogpen.

No. 10. A polluted supply. The field observations show this to be a more offensively polluted water than is indicated by the analytical data. By carefully protecting the mouth of the well with a good covering and discontinuing the use of the well pit as a refrigerator the supply could be rendered safe.

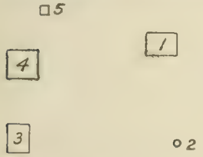

FIG. 43.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 10: 1, House; 2, well; 3, granary; 4, stables; 5, privy.

Location of farm.—Crookston, Minn.
Date of visit.—September 10, 1908.
Size.—Three hundred and twenty acres.
Kind of farming.—Grain.
Topography.—Level prairie.
Source of water supply.—(See fig. 43.) Well about 50 feet from stables; 180 feet in depth; casing, 2-inch iron pipe. *Strata:* Unknown, probably blue clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The 2-inch iron casing is carried to within 14 feet of surface and there empties its overflow into a well pit, which is cased with an iron casing about 2½ feet in diameter. The well pit contained several feet of water, on which were floating decomposed cream and other contaminations of surface origin.
Cisterns.—None.
Lakes, rivers, ponds, and springs.—None.
Sanitary condition of farmhouse and outbuildings.—House very poor; stables fair; privy poor, open vault and unprotected.
Milk.—Made into butter; sanitary care very poor.
Water-borne diseases.—Two cases of typhoid fever occurred during the summer of 1898. The same water supply was used at that time. The family having moved away, no definite data could be found regarding these cases.
Analyses.—See page 78.

No. 11. A polluted supply. The city of Crookston is located several miles from this farm, and a well sunk there for a municipal supply drained the well under discussion. This would seem to indicate that this well is connected with an extensive underground supply which may be polluted at a more or less distant point. Without considerable investigation it would be impossible to determine whether or not this supply is perfectly safe.

Location of farm.—Crookston, Minn.
Date of visit.—September 10, 1908.
Size.—One hundred and sixty acres.
Kind of farming.—Grain.
Topography.—Level prairie.
Source of water supply.—(See fig. 44.) Well about 30 feet from corner of stables; 203 feet in depth; casing, 2½-inch iron pipe. *Strata:* Blue clay, 20 feet; red clay, 150 feet; mixed sand and clay, 27 feet; rock, 3 feet; and fine sand, 3 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair; near barnyard and stable, yet for a well as deep and as carefully protected as this one little danger could be expected from that source. Casing extends to base of pump. Water rises to within 17 feet of surface.
Cisterns.—One, used for washing.
Lakes, rivers, ponds, and springs.—None.
Sanitary condition of farmhouse and outbuildings.—House poor; stables very poor; privy poor, open vault and unprotected.

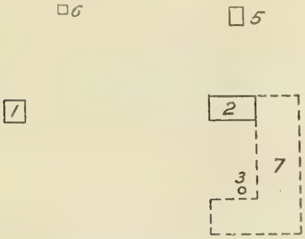

FIG. 44.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 11: 1, House; 2, stables; 3, well; 4, chicken house; 5, granary; 6, privy; 7, barnyard.

Milk.—Made into butter; sanitary care fair.
Water-borne diseases.—None recorded.
Analyses.—See page 78.

No. 12. A polluted supply. Although the surface protection of this well is good, the environment is bad; the pollution is probably due to seepage from the upper strata down the outside of the casing. For domestic use a well should be sunk farther from the stables and barnyard.

Location of farm.—Hallock, Minn.
Date of visit.—September 17, 1908.
Size.—Four hundred and eighty acres.
Kind of farming.—Grain.
Topography.—Level prairie.
Source of water supply.—(See fig. 45.) Well about 5 feet from stables; 75 feet in depth; casing, 2½-inch iron pipe. *Strata:* Hardpan and a clay mixture. *Yield:* Abundant, except in very dry seasons. *Use:* Drinking, when the supply of cistern water gives out, and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair; too near stables. Surface of well is thoroughly protected from surface wash and back flow.
Cisterns.—One, used for drinking, but was empty on date of visit.

Lakes, rivers, ponds, and springs.—A few ponds, dug for collecting surface water for watering cattle.

Sanitary condition of farmhouse and outbuildings.—House poor; stables good; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

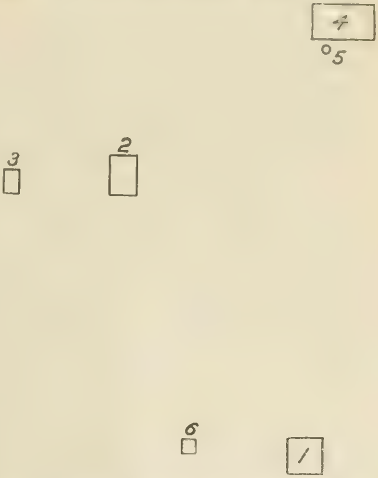

FIG. 45.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 12: 1, House; 2, feed house; 3, chicken house; 4, barn and stables; 5, well; 6, privy.

No. 13. A good supply. It is advisable to prevent collection of water in the well pit.

Location of farm.—Anoka, Minn.

Date of visit.—September 29, 1908.

Size.—Two hundred and thirty acres.

Kind of farming.—General.

Topography.—Level, sandy surface. Drainage is carried artificially in several directions.

Source of water supply.—(See fig. 46.) Well in pump house about 25 feet from house; 112 feet in depth; casing, 3-inch iron pipe; well pit 10 feet in depth, cased with wood. *Strata:* Sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, gasoline engine used for power. *Sanitary aspect:* Good. Well is protected from surface wash, yet a small quantity of back flow enters well pit; about 1 foot of water in well pit on date of visit. Casing extends to base of pump, so there is no opportunity for direct pollution.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables good; milk house good; privy good, open vault quite well protected.

Milk.—Cream shipped to St. Paul; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

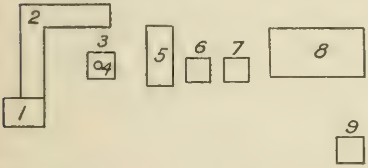

FIG. 46.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 13: 1, House; 2, wagon shed; 3, pump house; 4, well; 5, chicken house; 6, granary; 7, granary; 8, barn and stables; 9, granary.

DRIVEN WELLS.

No. 1. A good supply, except for the temporary pollution of the storage tank.

Location of farm.—Excelsior, Minn.

Date of visit.—June 30, 1908.

Size.—One hundred and forty acres.

Kind of farming.—General.

Topography.—Surface is irregular, sloping gradually toward the creek. The low, flat land surrounding the elevation is subject to overflow during the spring season.

Source of water supply.—(See fig. 47.) Well about 30 feet from house; 150 feet in depth; casing, 3-inch iron pipe. *Strata:* Surface clay, 10 feet; hardpan, 100 feet; gravel, 40 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump with windmill and gasoline engine for power. *Storage tank:* Wood, capacity 3,800 gallons. *Sanitary aspect:* Good. The well pit is dry and well protected from surface wash. A short time before date of visit the storage tank began to leak and the owner emptied several pecks of meal into the tank. The meal soon decomposed and gave the water a bad taste and odor. The cesspool is a considerable distance from the well.

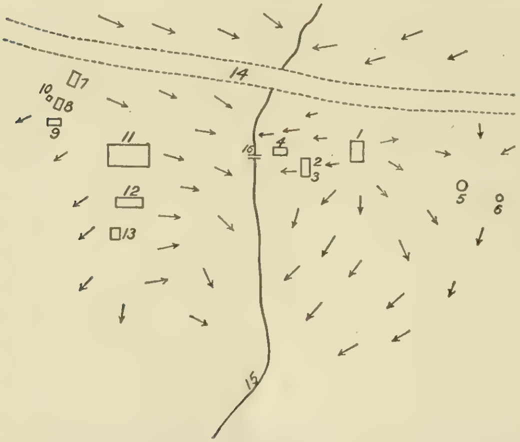

Fig. 47.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 1: 1, House; 2 and 3, pump house and elevated water tank; 4, ice house; 5, cesspool; 6, cesspool outlet; 7, farmhouse; 8, shed; 9, chicken coop; 10, privy; 11, barn; 12, shed; 13, corncrib; 14, road; 15, creek; 16, bridge.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—One lake, several springs, and one creek on farm.

Sanitary condition of farmhouse and outbuildings.—House very good; stables fair; privy good, connected with cesspool.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—For both well water and tank water, see page 79.

No. 2. A polluted supply. This could be made a safe supply by protecting the well pit from surface wash.

Location of farm.—New Brighton, Minn.

Date of visit.—July 3, 1908.

Size.—Forty acres.

Kind of farming.—General.

Topography.—The land in general slopes away from the house and outbuildings and toward the well. The yard and basements of stables are approximately 6 feet lower than surface of well.

Source of water supply.—(See fig. 48.) Well surrounded by farm buildings; 160 feet in depth; casing, 2-inch iron pipe, well protected at surface. *Strata:* Unknown. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Hand pump and windmill. *Sanitary aspect:* Fair. Slope toward well very gradual; in wet weather well pit fills with water.

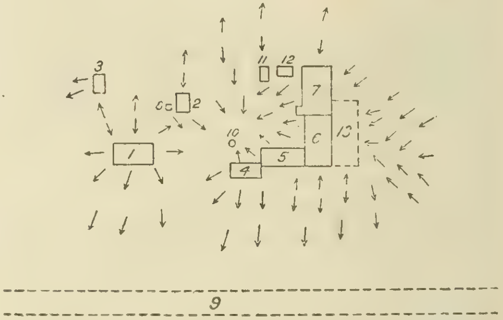

Fig. 48.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 2: 1, House; 2, ice house; 3, tool shed; 4, tool shed; 5, hay barn; 6, hay barn; 7, stables; 8, privy; 9, public road; 10, well; 11, corncrib; 12, corncrib; 13, barnyard.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stables very poor; privy poor, unprotected vault.

Milk.—Used on farm; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 3. A polluted supply. This well is in as bad a location as could be found on the farm and should be abandoned.

Location of farm.—St. Louis Park, Minn.

Date of visit.—July 6, 1908.

Size.—Sixty acres.

Kind of farming.—Dairy.

Topography.—The land surrounding buildings slopes abruptly from house and outbuildings in direction of stable and well. Well is about 3 feet lower than stable and 25 feet lower than house.

Source of water supply.—(See fig. 49.) Well is 10 feet from corner of stable; 60 feet in depth; casing, 2-inch iron pipe. *Strata:* Unknown. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Hand pump and windmill. *Sanitary aspect:* Very bad. Well is surrounded by manure heaps. The well pit, which is 10 feet deep, contained about 6 feet of manure leachings and surface wash; it sometimes completely fills. It seems that a worse location could scarcely be chosen for a well to be used for drinking purposes.

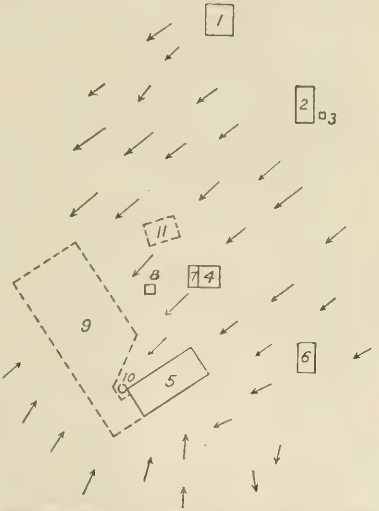

FIG. 49.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 3: 1, House; 2, storehouse and tool shed; 3, privy; 4, ice house; 5, stable; 6, chicken coop; 7, milk room; 8, hogpen; 9, barnyard; 10, well; 11, hay yard.

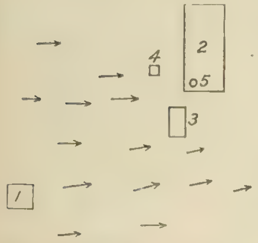

FIG. 50.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 4: 1, House; 2, barn and stable; 3, milk house; 4, privy; 5, well.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—A few ponds scattered about the farm.

Sanitary condition of farmhouse and outbuildings.—House very poor; milk house very bad; privy poor, unprotected vault.

Milk.—Retailed in city; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 4. A polluted supply. Both well and stables should be removed to higher ground.

Location of farm.—Minneapolis Minn.

Date of visit.—July 8, 1908.

Size.—One hundred and eighty acres.

Kind of farming.—Dairy.

Topography.—The surface falls abruptly from house to stable, a difference in elevation of about 20 feet.

Source of water supply.—(See fig. 50.) Well in corner of cow stables; 20 feet in depth, driven 10 feet and dug 10 feet; casing, wood and iron. *Strata:* Surface soil, 3 feet;

and sand, 17 feet; a ledge of rock forms bottom of well. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Hand pump and gasoline engine. *Sanitary aspect:* Very bad. The well pit usually contains from 1 to 2 feet of washings from under stable floor and back flow from pump.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables fair; privy poor, unprotected vault.

Milk.—Retailed in Minneapolis; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 5. A polluted supply. By good surface protection the condition of the water could be much improved, though for domestic use a well should be sunk in a more sanitary location.

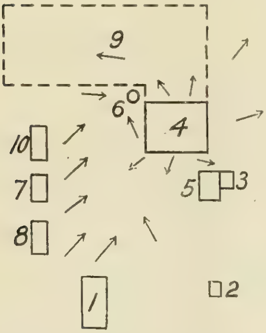

FIG. 51.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 5: 1, House; 2, privy; 3, corncrib; 4, barn and stables; 5, milk house and storehouse; 6, well; 7, stone house; 8, icehouse; 9, barnyard; 10, wagon shed.

Location of farm.—Richfield, Minn.

Date of visit.—July 10, 1908.

Size.—Ninety acres.

Kind of farming.—Dairy.

Topography.—Drainage from most of the outbuildings finally reaches the barnyard at several points near the well.

Source of water supply.—(See fig. 51.) Well about 10 feet from corner of stables and same distance from barnyard; 50 feet in depth; casing, 1½-inch iron pipe. *Strata:* Unknown. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump; windmill for power. *Sanitary aspect:* Bad. Seepage and surface water from all directions flows directly into the well pit, sometimes standing several feet deep. The water pumped from the well had a decided odor.

Cisterns.—One, under house, but not used.

Lakes, rivers, ponds, and springs.—Lake Grass, a small shallow lake used only to water cattle.

Sanitary condition of farmhouse and outbuildings.—House fair; milk house poor; stables poor; privy poor, unprotected vault.

Milk.—Retailed in Minneapolis; sanitary care poor.

Water-borne diseases.—Last year three typhoid patients were cared for on this farm but all lived in Minneapolis when taken with the disease. The data at hand indicate that the typhoid was contracted in the city. It seems strange that the disease did not spread to those living on the farm.

Analyses.—See page 79.

No. 6. A good supply. There are other places in this yard that would be more suitable for the water supply.

Location of farm.—Minneapolis, Minn.

Date of visit.—July 10, 1908.

Size.—Two hundred and thirty acres.

Kind of farming.—General.

Topography.—The house is about 5 feet above the outbuildings. The drainage from most of the outbuildings is in the direction of the pond in the barnyard.

Source of water supply.—(See fig. 52.) Well within a few feet of barnyard and about 15 feet from barn; 40 feet in depth; casing, 1½-inch iron pipe. *Strata:* Sandy soil. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Hand pump; windmill for power. *Sanitary aspect:* Fair. The barnyard and other outbuildings form a rather dangerous environment. The surface of the well is quite well protected and the well pit was perfectly dry on date of visit.

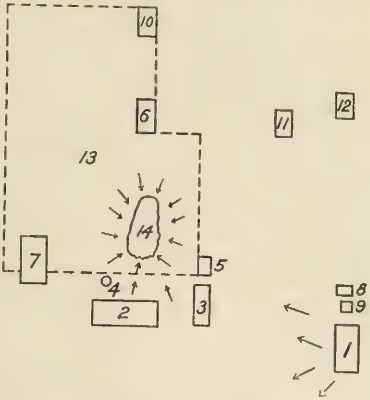

FIG. 52.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 6; 1, House; 2, horse barn; 3, corncrib; 4, well; 5, ice house; 6, granary; 7, cow stables; 8, wood shed; 9, privy; 10, sheep shed; 11, stone house; 12, storehouse; 13, barnyard; 14, pond.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—Lake Wood, used at times to water cattle.

Sanitary condition of farmhouse and outbuildings.—Good.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 7. A polluted supply. Good protection against surface wash and seepage from the upper strata would greatly improve this supply. It is too near the stable, however.

Location of farm.—St. Paul, Minn.

Date of visit.—July 15, 1908.

Size.—Three acres.

Kind of farming.—Dairy.

Topography.—Low, level ground.

Source of water supply.—(See fig. 53.) Well in combined pump and milk house; 30 feet in depth; casing, 1½-inch iron pipe. *Strata:* Unknown; probably sandy loam. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill for power. *Sanitary aspect:* Bad. A well pit 3 feet square cased with ordinary wood casing extends to a depth of about 8 feet and contains several feet of surface wash and back flow from the pump. The mouth of the well pit is at a lower level than the stables and the house.

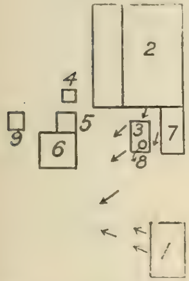

FIG. 53.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 7: 1, House; 2, hay barn and stables; 3, milk house; 4, privy; 5, stone house; 6, wood shed; 7, wagon shed; 8, well; 9, tool shed.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables fair; milk house fair; privy poor, unprotected vault.

Milk.—Retailed in St. Paul; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 8. A polluted supply. This supply could be made safe by installing a tight casing for the well pit and fitting a good cover around the base of the pump.

Location of farm.—St. Paul, Minn.

Date of visit.—July 15, 1908.

Size.—Ten acres.

Kind of farming.—Dairy.

Topography.—The surface slopes very abruptly from the points marked *x* (see fig. 54) in the direction of the outbuildings which are located on the level marked *y*. The difference in elevation between *x* and *y* is about 25 feet; a fall of probably 6 feet was noted between points *y* and *z*. The house and privy are located at a point intermediate between *x* and *y*, probably 15 feet above the other outbuildings.

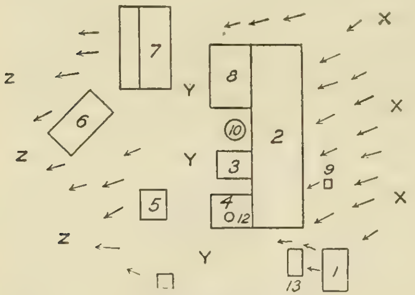

FIG. 54.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 8: 1, House; 2, cow stables; 3, horse stables; 4, well and tank house; 5, stone house; 6, storehouse; 7, cow stables; 8, hay shed; 9, privy; 10, silo; 11, old windmill base; 12, well; 13, stone house.

Source of water supply.—(See fig. 54.) Well in combined pump and milk house; 119 feet in depth; casing, 2½-inch iron pipe. *Strata:* Sand, 25 feet; the remainder clay and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Well pit 7 feet deep, cased with wood. The mouth of well pit is quite well protected from surface wash. The well is too near the stables and privy, and during wet seasons it would seem almost impossible to prevent seepage into the well pit from these sources.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables fair; milk house very poor; privy poor, open vault and unprotected.

Milk.—Retailed in St. Paul; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 9. A good supply.

Location of farm.—St. Paul, Minn.

Date of visit.—July 17, 1908.

Size.—Eighty acres.

Kind of farming.—Dairy.

Topography.—The house is about 3 feet above the well and about 12 feet above the stables. The general slope is away from the house in the direction of the well and outbuildings.

Source of water supply.—(See fig. 55.) Well about 20 feet from house; 57 feet in depth, 22 feet dug and 35 feet driven, dug part filled to about 10 feet of surface; casing, 1½-inch iron pipe. *Strata:* Clay, 50 feet, and sand, 7 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Good.

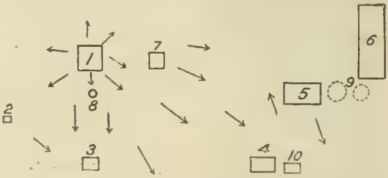

FIG. 55.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 9: 1, House; 2, privy; 3, outdoor kitchen; 4, tool and wagon shed; 5, horse barn; 6, cow stables; 7, milk house; 8, well; 9, silos; 10, tool shed.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables in bad location and receive little attention; milk house well cared for; privy poor, unprotected vault.

Milk.—Retailed in St. Paul; sanitary care good.

Water-borne diseases.—None recorded.
Analyses.—See page 79.

No. 10. A good supply.

Location of farm.—Red Wing, Minn.
Date of visit.—July 23, 1908.
Size.—Seventy acres.
Kind of farming.—Dairy and general.
Topography.—The house is located on a level strip of ground sloping in three directions and is about 10 feet above the outbuildings.
Source of water supply.—(See fig. 56.) Well in milk room at back of house; 20 feet in depth; casing, $1\frac{1}{4}$-inch iron pipe; well pit, 10 feet deep and 3 feet in diameter. *Strata:* Surface soil, 5 feet, and sand, 15 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good. The wash water and soluble wastes from the house are carried by a tile drain pipe to the edge of the marsh some 4 rods distant.
Cisterns.—None.
Lakes, rivers, ponds, and springs.—Hay Creek, a small creek near back of house.
Sanitary condition of farmhouse and outbuildings.—House good; stables poor; privy poor, unprotected vault.
Milk.—Sold in Red Wing; sanitary care good.
Water-borne diseases.—None recorded.
Analyses.—See page 79.

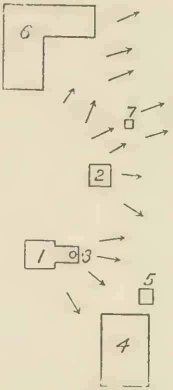

FIG. 56.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 10: 1, House; 2, ice house; 3, well; 4, stables; 5, milk house; 6, barn and stables; 7, privy.

No. 11. A good supply. This may, however, become polluted unless the well pit is kept clean and dry.

Location of farm.—Morris, Minn.
Date of visit.—August 10, 1908.
Size.—Two hundred and forty acres.
Kind of farming.—General.
Topography.—The well is about $1\frac{1}{2}$ feet above house and stables. The general slope is away from the well in all directions.
Source of water supply.—(See fig. 57.) Well about 25 feet from stables; 182 feet in depth; casing, $2\frac{1}{2}$-inch iron pipe. *Strata:* Clay, 70 feet, and gravel and sand, 112 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair. The well pit, which is 12 feet deep and cased with boards, is used as a storage reservoir and is constantly over half full of water. The water from the pit is used for cattle only. There is always danger of a filled pit leaking into the well through defective casing. The covering is of loose boards.

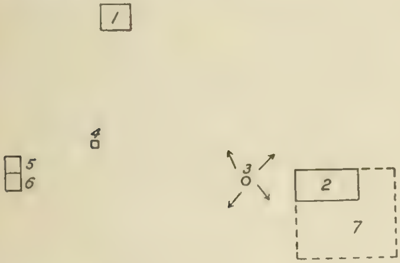

FIG. 57.—Sketch showing the topography and the location of buildings in the vicinity of driven well No 11: 1, House; 2, barn and stables; 3, well; 4, privy; 5, ice house; 6, tool shed; 7, barnyard

Cisterns.—One, under house, used for washing and at times for drinking, but owner stated that they never drank this water unless it had been boiled.

Lakes, rivers, ponds, and springs.—Two ponds which contain water all the year.

Sanitary condition of farmhouse and outbuildings.—House excellent; stables good; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care good.

Water-borne diseases.—One case of typhoid on this farm eighteen years previous to date of visit, but a different source of water supply was used at that time. No definite data could be obtained regarding the case.

Analyses.—See page 79.

No. 12. A good supply. This supply must be given exceptional care, especially against surface wash from the barnyard. The use of the well pit for refrigeration is inadvisable. It would be best to sink a well for domestic supply some distance from the barnyard and outbuildings.

Location of farm.—Henning, Minn.

Date of visit.—August 11, 1908.

Size.—One hundred and sixty acres.

Topography.—Perfectly level.

Source of water supply.—(See fig. 58.) Well 25 feet from house and 175 feet from stables at edge of barnyard; 24 feet in depth, 16 dug and 8 driven; casing, 2-inch boards in dug portion and 2-inch iron pipe in driven portion. *Strata:* Clay, 8 feet, and sand, 16 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair. As the number of animals cared for in the barnyard increases the well may become polluted. The covering is in poor condition; the planks are left loose so that they can be removed and pails of milk, etc., suspended in the well. On date of visit the dug portion contained several feet of water.

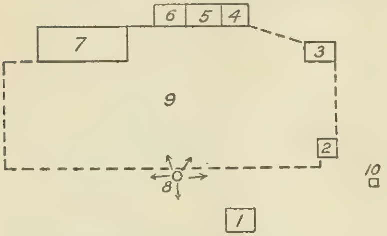

FIG. 58.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 12; 1, House; 2, tool shed; 3, granary; 4, hogpen; 5, wagon shed; 6, chicken house; 7, barn and stables; 8, well; 9, barnyard; 10, privy.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables good; milk house excellent; privy poor, open vault and unprotected.

Milk.—Cream sold to butter factory; sanitary care good.

Water-borne diseases.—Two cases of typhoid fever have occurred on this farm; a girl, age 16, taken sick July 14, 1908, and a boy, age 14, taken sick July 25. The entire family, numbering seven persons, had attended two circuses a short time previous to the infection of the first case. The first circus attended was at Wadena, Minn., June 27, on which occasion all the family drank water from several sources in Wadena as well as on the train, and also drank circus lemonade. The second circus was at Henning, July 10; on this occasion both of the infected people drank water from several sources in Henning. Judging from the date of the first appearance of the infection, it would seem reasonable to think the disease was contracted at Wadena. The second case might have been infected from the original source, but more probably was infected from the first case.

Analyses.—See page 79.

No. 13. A polluted supply. This may be due to bad water used for priming, but is more probably due to a too rapid inflow from the river. Sinking a well at a greater distance from the river and installing a good pump would give a good supply.

Location of farm.—Crookston, Minn.

Date of visit.—September 11, 1908.

Size.—Three hundred and twenty acres.

Kind of farming.—Grain.

Topography.—Surface very broken; slope in direction of Red Lake River. Elevation of principal buildings about 25 feet above river.

Source of water supply.—(See fig. 59.) Well about 25 feet from Red Lake River, surface elevation about 20 feet above bed of river; 12 feet in depth; casing, $1\frac{1}{2}$-inch iron pipe. *Strata:* Sand, 4 feet; clay, 4 feet; and sand, 4 feet. *Yield:* Insufficient. *Use:* Drinking and general farm purposes. *Method of lifting:* Cistern pump. *Sanitary aspect:* Fair. Far enough from buildings to be safe from such pollution and surface well protected except for priming the pump. This well may receive a direct flow from the river, as the water supply follows very closely its rise and fall.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Red Lake River flows through farm and is used for drinking and other purposes.

Sanitary condition of farmhouse and outbuildings.—House good; stables very poor; privy poor, open vault and unprotected.

Milk.—Cream sold to butter factory; sanitary care fair.

Water-borne diseases.—Two cases of typhoid fever occurred on this farm in the spring of 1908, a girl 19 years old taken sick February 10, and a boy 13 years old taken sick March 10. The first patient had not been away from the farm for at least six weeks previous to the infection, as during the cold weather the people in this back country move about very little. The water used in the winter for drinking purposes is taken from the Red Lake River and no well water is used. The second patient had been around the neighborhood but not to any adjoining towns during the period of infection. The physician and family lay the source of infection to the river water, and judging from other cases in the same vicinity this is undoubtedly the source. The second case might be contact or from the original source, the river, for the family drank the river water until February 25.

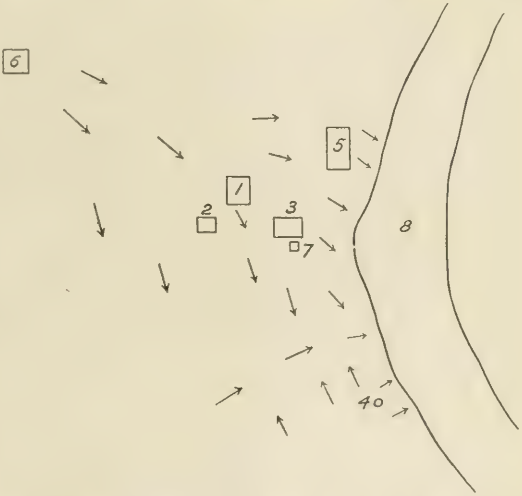

FIG. 59.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 13: 1, House; 2, granary; 3, hogpen; 4, well; 5, stables; 6, granary; 7, privy; 8, Red Lake River.

Analyses.—See page 79.

No. 14. A polluted supply. Thorough surface protection might make this a good supply. It would be better, however, to sink a well farther from the stable and barnyard.

Location of farm.—Crookston, Minn.

Date of visit.—September 11, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Level prairie.

Source of water supply.—(See fig. 60.) Well about 5 feet from stable; 25 feet in depth, dug 20 feet and driven 5 feet; casing, 1½-inch pipe. *Strata:* Blue prairie clay. *Yield:* Insufficient during dry season. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The poor covering allows surface wash to enter. The dug portion contains several feet of water and gives off a bad odor when cover is removed. From the color of the pump water it is evident that this offensive water from the dug portion reaches the well proper.

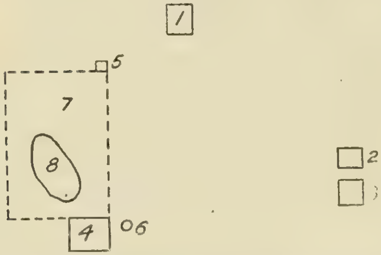

Fig. 60.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 14: 1, House; 2, granary; 3, granary; 4, stables; 5, privy; 6, well; 7, barnyard; 8, pond.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—One pond in barnyard.

Sanitary condition of farmhouse and outbuildings.—House very poor; stable very poor; privy very poor, open vault and unprotected.

Milk.—Made into butter; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 15. A good supply.

Location of farm.—Gladstone, Minn.

Date of visit.—July 20, 1908.

Size.—Forty acres.

Kind of farming.—General.

Topography.—The ground surrounding house and outbuildings is level with the exception of a slight incline near shore of lake. House is about 1½ feet above lake.

Source of water supply.—(See fig. 61.) Well 3 feet from house and 35 feet from lake; 65 feet in depth; casing, 1½-inch iron pipe; well pit, 10 feet deep, in good, dry condition. *Strata:* Unknown. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Round Lake, a small circular lake probably 40 rods at greatest width.

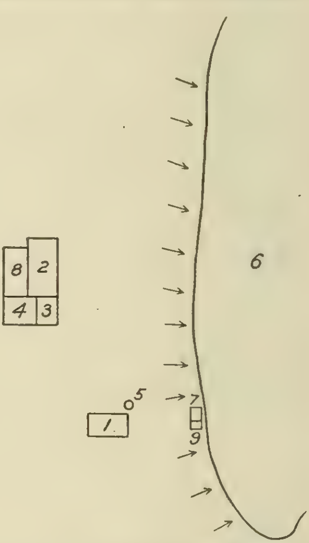

Fig. 61.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 15: 1, House; 2, stables; 3, stables; 4, wagon shed; 5, well; 6, Round Lake; 7, wood shed; 8, stable; 9, privy.

Sanitary condition of farmhouse and outbuildings.—House good; stables good; privy, open vault and unprotected.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 16. A good supply. The location of this supply is too near the house and privy, yet the natural sand filter will keep it safe under the existing conditions. Improved surface protection is advisable, especially if the draft upon the well is increased.

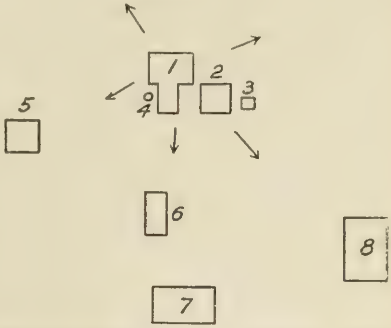

FIG. 62.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 16; 1, House; 2, ice house; 3, privy; 4, well; 5, wagon shed; 6, chicken coop; 7, hay barn; 8, stables.

Location of farm.—Anoka, Minn.

Date of visit.—September 29, 1908.

Size.—One hundred and eighty acres.

Kind of farming.—General.

Topography.—Level ground of a sandy surface character. Surface adjacent to house is artificially elevated about 1 foot above surrounding ground. Drainage in all directions away from house and well.

Source of water supply.—(See fig. 62.) Well about 5 feet from house; 36 feet in depth, dug 28 feet and driven 8 feet; casing, dug portion bricked, driven portion 1½-inch iron pipe. *Strata:* Sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Privy 50 feet away on slightly lower ground. Back flow from pump enters dug portion of well. Covering in poor condition.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Round Lake touches one side of farm, and a small river, outlet to the lake, flows through part of farm.

Sanitary condition of farmhouse and outbuildings.—House good; stables fair; privy very poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 17. A good supply. The surroundings are very unsanitary, and although the natural filtration of the upper strata may protect the water indefinitely it would be advisable to sink a well in a better place for domestic use.

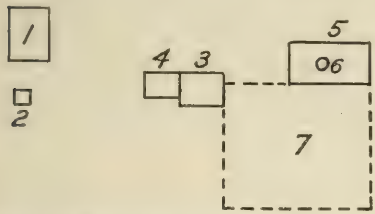

FIG. 63.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 17: 1, House; 2, privy; 3, granary; 4, wagon shed; 5, stables; 6, well; 7, barnyard.

Location of farm.—Anoka, Minn.

Date of visit.—September 29, 1908.

Size.—One hundred and forty-five acres.

Kind of farming.—General.

Topography.—Level prairie; surface soil sandy.

Source of water supply.—(See fig. 63.) Well in farm barn; 40 feet in depth; casing, 1½-inch iron pipe. *Strata:* Sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron cistern pump. *Sanitary aspect:* Bad. Well is located in stable directly between the horse and cow stalls, and the drainage from the dirt floor of the stables forms a puddle around the well pipe.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Several ponds, permanent throughout the year.

Sanitary condition of farmhouse and outbuildings.—House poor; stables poor; privy poor, open vault and unprotected.

Milk.—Cream shipped to St. Paul; sanitary care very poor.

Water-borne diseases.—One case of typhoid. The patient, a man 38 years old, was taken sick October 10, 1907, while repairing the public road near his house. Previous to his illness he drank water at several of the neighboring wells, though no other cases of typhoid developed in the neighborhood. On September 19, 20, and 21 the patient attended a street fair at Anoka and drank water from the city fountain several times. Several cases of typhoid were present in the city of Anoka and were supposed to have derived their infection from the city supply. The water supply of Anoka is taken from the Rum River, which has been found to be polluted.[a] One of the State insane asylums is located a short distance above the city and turns its sewage into the river after partial purification.

Analyses.—See page 79.

No. 18. A good supply. This supply will eventually become polluted unless the mouth and well pit are given better protection against surface wash and drainage from the upper strata.

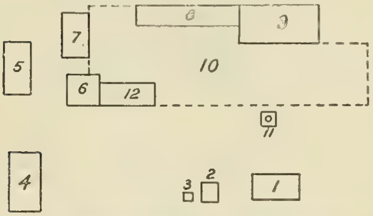

FIG. 64.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 18: 1, House; 2, wood shed; 3, privy; 4, tool shed; 5, tool shed; 6, granary; 7, hog-pen; 8, stables; 9, barn and stables; 10, barnyard; 11, well; 12, tool shed.

Location of farm.—Anoka, Minn.

Date of visit.—September 29, 1908.

Size.—Two hundred acres.

Kind of farming.—General.

Topography.—Level prairie; sandy surface. Artificial drainage in several directions.

Source of water supply.—(See fig. 64.) Well in pump house; 28 feet in depth; casing, 1½-inch iron pipe; well pit 10 feet deep, cased with wood. *Strata:* Sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad, located at edge of barnyard. Drinking tank for cattle about 5 feet from well and surrounded by mud. Well pit contains about 1 foot of water as back flow and surface wash.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables poor; privy poor, open vault and unprotected.

Milk.—Cream retailed in Anoka; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 19. A good supply. This supply is in danger of becoming polluted by seepage from the well pit. A good covering should be installed, and a drain ditch should lead off the water from the cattle trough.

Location of farm.—Anoka, Minn.

Date of visit.—September 29, 1908.

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[a] Determination made by Minnesota State Board of Health.

Size.—Thirty acres.

Kind of farming.—General.

Topography.—Level ground of a sandy surface type. Drainage in no special direction.

Source of water supply.—(See fig. 65.) Well about 40 feet from house; 25 feet in depth; casing, 1½-inch iron pipe; well pit 10 feet deep, cased with wood. *Strata:* Sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair. Well about 30 feet from barnyard. Watering trough for cattle a few feet from well and surrounded by mud. Covering in very poor condition, so back flow from pump enters freely. Well pit contains several inches of water.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables poor; privy poor, open vault and unprotected.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

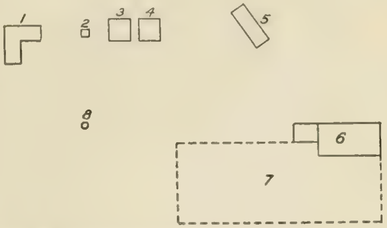

Fig. 65.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 19: 1, House; 2, privy; 3, tool shed; 4, corncrib; 5, chicken house; 6, barn and stables; 7, barnyard; 8, well.

SPRINGS.

No. 1. A polluted supply. This supply could be made safe and attractive by proper protection against water from the surface and upper strata. The privy should be moved to a greater distance and preferably to a lower level.

Location of farm.—Minneapolis, Minn.

Date of visit.—July 8, 1908.

Size.—Thirty-five acres.

Kind of farming.—Dairy.

Topography.—The surface slopes from house and outbuildings toward the barn; a difference in elevation of about 8 feet. The land on the opposite side of the barn from the house is low and marshy.

Source of water supply.—(See fig. 66.) Spring on sloping ground surrounded by outbuildings; dug down about 10 feet and cased with wood. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Sanitary aspect:* Bad. The spring is so located that with care good water could be secured; unfortunately, however, the privy is only about 20 feet away and the spring is poorly protected.

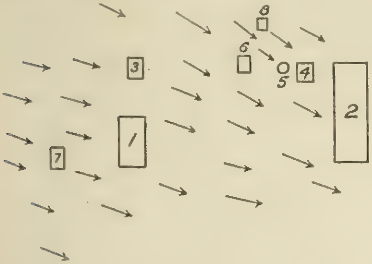

Fig. 66.—Sketch showing the topography and the location of buildings in the vicinity of spring No. 1: 1, House; 2, barn and stables; 3, wood shed; 4, milk house; 5, spring; 6, tool shed; 7, outdoor kitchen; 8, privy.

Cisterns.—None.

Lakes, rivers, ponds, and wells.—None.

Sanitary condition of farmhouse and outbuildings.—House good; outbuildings fair; privy poor, unprotected vault.

Milk.—Retailed in Minneapolis; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 2. For a description of this spring, see cistern No. 3, under the heading "Lakes, rivers, ponds, and springs," page 66.

RIVERS.

No. 1. A polluted supply. It is impracticable to try to purify polluted river water for farm use. Wells should be used for the domestic supply at least.

The main supply for this farm is a dug well, although the river water has been used during the winter season. For description, see No. 26, under the heading "Dug wells."

No. 2. A polluted supply. It is impracticable to try to purify polluted river water for farm use. Wells should be used for the domestic supply at least.

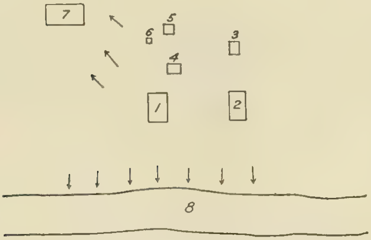

FIG. 67.—Sketch showing the topography and the location of buildings in the vicinity of river No. 2: 1, House; 2, blacksmith shop; 3, chicken house; 4, wood shed; 5, chicken house; 6, privy; 7, stable; 8, Red Lake River.

Location of farm.—Huot, Minn.

Date of visit.—September 11, 1908.

Size.—One acre.

Kind of farming.—General.

Topography.—Drainage from the farm buildings is chiefly away from the river.

Source of water supply.—(See fig. 67.) Well; see report No. 26 under "Dug wells" for description of well which was also used by this family.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Red Lake River forms the southern boundary of the property and served as a water supply during the winter until typhoid fever developed.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor. privy very poor, open vault entirely unprotected.

Milk.—Used on farm; sanitary care very poor.

Water-borne diseases.—Three cases of typhoid fever occurred on this place during February, March, and April, 1908. The first, a boy 10 years old, was taken sick about February 15; the second, a man 40 years old, February 28, and the third, a boy 7 years old, April 19. All of these people drank river water from the Red Lake River from September 30 until March 15, on which date the doctor in charge decided the river water to be the source of infection.

Analyses.—See page 79.

No. 3. A polluted supply. It is impracticable to try to purify polluted river water for farm use. Wells should be used for the domestic supply at least.

Location of farm.—Thief River Falls, Minn.

Date of visit.—September 14, 1908.

Size.—Seventy-seven acres.

Kind of farming.—General.

Topography.—House and outbuildings 20 feet above Red Lake River. Entire drainage from yards is in direction of river.

Source of water supply.—(See fig. 68.) Red Lake River.

Cisterns.—None.

Lakes, wells, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor; privy very poor, open vault and unprotected. This is a typical pioneer residence. The property was formerly part of the Red Lake Indian Reservation and has recently been taken up by settlers.

Milk.—Sold to creamery; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 4. A polluted supply. It is impracticable to try to purify polluted river water for farm use. Wells should be used for the domestic supply at least.

The main supply for this farm is a driven well, although the river water has been used during the winter season. For description, see No. 13, under the heading "Driven wells."

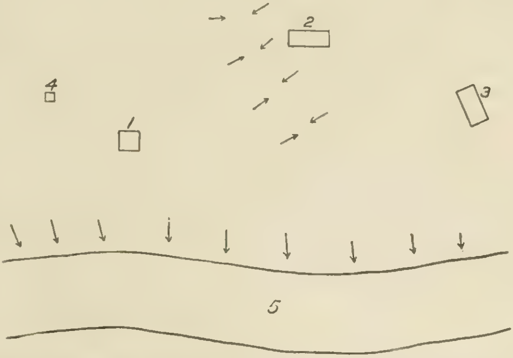

FIG. 68.—Sketch showing the topography and the location of buildings in the vicinity of river No. 3: 1, House; 2, chicken house; 3, stables; 4, privy; 5, Red Lake River.

SURFACE RESERVOIRS.

No. 1. For a description of this reservoir, see cistern No. 1, under the heading "Lakes, rivers, ponds, and springs," p. 64.

No. 2. For a description of this reservoir, see cistern No. 2, under the heading "Lakes, rivers, ponds, and springs," p. 65.

CISTERNS.

No. 1. A polluted supply. The roof is the source of pollution, and unless sufficient water for a thorough rinsing of the roof can be wasted at the beginning of each rain it will be impossible to improve the water supply. Under such conditions the water for drinking should be boiled or otherwise disinfected.

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[a] Moore, G. T., and Kellerman, K. F. Methods of Destroying or Preventing the Growth of Algæ and Certain Pathogenic Bacteria in Water Supplies. Bureau of Plant Industry, Bul. 64. 1904.

Kraemer, Henry. The Copper Treatment of Water. American Journal of Pharmacy, vol. 76, No. 12, pp. 574–579. 1904.

Lewis, Frank C. The Sterilization of Water. Public Health Engineering, vol. 16, No. 415, p. 350. London, 1905.

Maignen, P. A. Different Methods of Purifying Water. Proceedings of the Engineers' Club of Philadelphia, vol. 24, No. 1, pp. 1–69. 1907.

Location of farm.—Kennedy, Minn.
Date of visit.—September 15, 1908.
Size.—Twelve thousand acres.
Kind of farming.—General and grain.
Topography.—Farm buildings located on level prairie land.

Source of water supply.—(See fig. 69.) Cistern under farmhouse kitchen. *Type:* Dug, with brick casing lined with cement; circular, with conical arched roof. *Capacity:* Two hundred barrels. *Use:* Drinking and general house purposes. *Method of lifting:* Cistern pump. *Sanitary aspect:* Fair. There are two openings, a circular manhole at the top and a small 4-inch opening in the side near the roof. The manhole is well protected with a tight board cover. A small well-protected pipe for carrying water into the cistern leads to the opening in the side, which pipe affords the only means of ventilation. An odor was complained of which could possibly be eliminated by better ventilation.

Lakes, rivers, ponds, and springs.—A second source of water supply for this farm is a shallow surface reservoir. This reservoir was scooped out of the surface soil and allowed to fill with surface water during the spring season, and it constitutes a supply for general farm use. It is about 60 feet long and 40 feet wide. The water is partly filtered by being passed to a well pit through a ditch dug in the clay and filled with gravel; however, this improves the condition of the water very little. The water is pumped from the well pit. The sanitary aspect is very bad; the water is entirely unprotected and is grossly polluted. On the date of visit it contained a large quantity of vegetable growth.

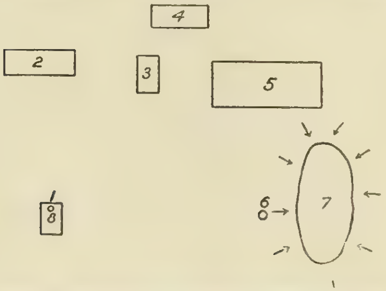

FIG. 69.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 1: 1, House; 2, granary; 3, wagon shed; 4, feed house; 5, barn and stables; 6, well pit; 7, reservoir; 8, cistern.

Sanitary condition of farmhouse and outbuildings.—House good; stables very good; privy good, open vault well protected.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 2. A polluted supply. The roof is the source of pollution, and unless sufficient water for a thorough rinsing of the roof can be wasted at the beginning of each rain it will be impossible to improve the water supply. Under such conditions the water for drinking should be boiled or otherwise disinfected.

Location of farm.—Kennedy, Minn.
Date of visit.—September 15, 1908.
Size.—One thousand acres.
Kind of farming.—General and grain.
Topography.—Level prairie land.

Source of water supply.—(See fig. 70.) Cistern under kitchen of farmhouse. *Type:* Dug, with brick casing lined with cement; circular, with conical arched roof. *Capacity:* One hundred and fifty barrels. *Use:* Drinking and general house purposes. *Method of lifting:* Cistern pump. *Sanitary aspect:* Fair. Surface in good condition and opening for entrance of water well protected.

Lakes, rivers, ponds, and springs.—A surface reservoir is used for an additional supply for cattle, and in case of necessity for drinking. It is dug in clay soil, and its approximate dimensions are 60 feet long, 35 feet wide, and 6 feet deep. It is allowed to fill with surface water during the winter and spring, and the heavy clay soil holds the water throughout the summer. The sanitary conditions surrounding this supply are very bad. Surface wash from the barnyard enters freely; decaying vegetable growths could be seen in water on date of visit. The water is pumped directly from the reservoir by means of a wooden pump suspended on a platform built over the water. These surface water supplies are necessarily used on account of the impracticability of a deep ground supply or of a surface well. The deep ground waters of this area are very salty and in most cases have a strong alkaline taste, which renders them impossible for domestic or farm use.

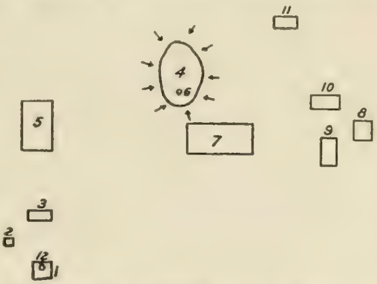

FIG. 70.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 2: 1, House; 2, privy; 3, wood shed; 4, reservoir; 5, tool shed; 6, pump; 7, barn and stables; 8, granary; 9, chicken coop; 10, granary; 11, hogpen; 12, cistern.

Sanitary condition of farmhouse and outbuildings.—House very good; stables very good; privy good, open vault well protected.

Milk.—Used by family; sanitary care very good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 3. A polluted supply. The roof is the source of pollution, and unless sufficient water for a thorough rinsing of the roof can be wasted at the beginning of each rain it will be impossible to improve the water supply. Under such conditions the water for drinking should be boiled or otherwise disinfected.

Location of farm.—Hallock, Minn.

Date of visit.—September 16, 1908.

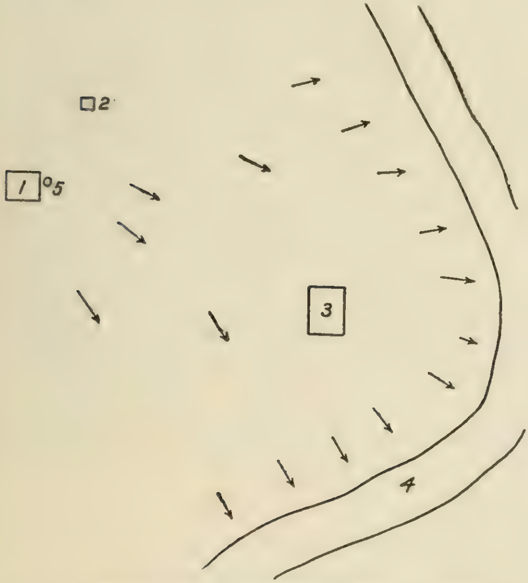

FIG. 71.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 3: 1, House; 2, privy; 3, stables; 4, creek; 5, cistern.

Size.—Two hundred and forty acres.

Kind of farming.—General.

Topography.—Surface undulating; buildings on banks of creek; house about 5 feet higher than barn, 30 feet higher than creek.

Source of water supply.—(See fig. 71.) Cistern at side of house. *Type:* Dug, with galvanized iron casing; circular, with flat top. *Capacity:* Sixty barrels. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good. Cistern appears to be well protected in every way; surface of galvanized tank tightly covered with boards; top projects some few feet above surface of ground and thus eliminates all danger of surface water entering.

Lakes, rivers, ponds, and springs.—An interesting feature on this farm is a salt spring. It is very troublesome, as it flows into a small creek near the farm buildings and completely ruins the water for all farm purposes. The flow is probably no more than several barrels an hour, but even this small quantity is sufficient to impart a bad taste to the creek water. This spring water is quite similar in taste and appearance to the water in the few wells in that vicinity. A sample was collected for the purpose of studying the character of these disagreeable ground waters of the Red River Valley district.

Sanitary condition of farmhouse and outbuildings.—House good; stables fair; privy poor, open vault entirely unprotected.

Milk.—Made into butter; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

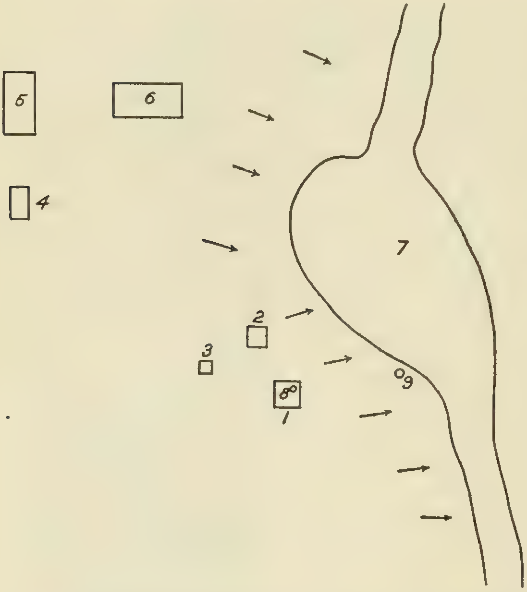

FIG. 72.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 4: 1, House; 2, ice house; 3, privy; 4, tool shed; 5, stables; 6 granary; 7, creek; 8, cistern; 9, well.

No. 4. This is a badly polluted supply. The roof is the source of pollution, and unless sufficient water for a thorough rinsing of the roof can be wasted at the beginning of each rain it will be impossible to improve the water supply. Under such conditions the water for drinking should be boiled or otherwise disinfected.

Location of farm.—Hallock, Minn.

Date of visit.—September 16, 1908.

Size.—Six hundred and forty acres.

Kind of farming.—Grain.

Topography.—Drainage from the farm buildings flows in the direction of the creek.

Source of water supply.—(See fig. 72.) Two cisterns in cellar of house. *Type:* Galvanized iron tanks; circular, with flat bottoms. *Capacity*: One hundred barrels each. *Use:* Drinking and general house purposes. *Method of lifting:* Water dipped from tanks with pails. *Sanitary aspect:* Poor. The tanks were in excellent condition, but lacked coverings to protect them from dust and such other material as might fall from the floor above. The tin pipe leading from roof to tanks is provided with a sort of filter, consisting of a rectangular tin box 12 inches by 5 inches by 5 inches, with a conical bottom. Bags of charcoal the proper size to fit this box are placed in it, and the water in flowing to the tanks must necessarily pass through this filter. The bags are removed after each rain and replaced by clean bags of the same material.

Lakes, rivers, ponds, and springs.—One creek.

Sanitary condition of farmhouse and outbuildings.—House fair; stables fair; privy poor, open vault, entirely unprotected.

Milk.—Made into butter; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 5. A polluted supply. The cistern needs a thorough cleaning. With proper covering the condition of the cistern could be improved, and by wasting the first rinsing from the roof at the beginning of each rain the water might be kept in good condition.

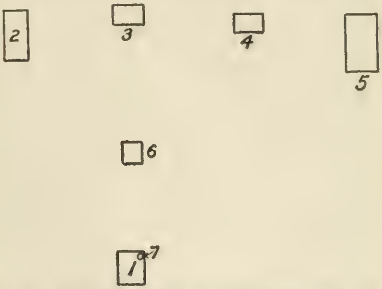

FIG. 73.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 5: 1, House; 2, granary; 3, tool shed; 4, hogpen; 5, stables; 6, wood shed and privy; 7, cistern.

Location of farm.—Hallock, Minn.

Date of visit.—September 17, 1908.

Size.—Four hundred and eighty acres.

Kind of farming.—Grain.

Topography.—Level prairie land.

Source of water supply.—(See fig.73.) Cistern under kitchen. *Type:* Dug, with brick casing lined with cement; round, with conical roof. *Capacity:* One hundred barrels. *Use:* Drinking and general house purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The covering is in very poor condition and the water has a strong odor of decaying organic matter.

Lakes, rivers, ponds, and springs.—Several ponds have been dug to collect water for watering cattle.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables good; privy poor, open vault, entirely unprotected.

Milk.—Made into butter; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

TABULATION OF SANITARY SURVEYS.

The following tables give full information in regard to the sanitary surveys, including analyses:

TABLE I.—*Location, size, and other details of farms in Minnesota on which an investigation of water supplies was made.*

DUG WELLS.

No.	Location.	Date of visit.	Size.	Kind of farming.	Topography.	
					Character of surface.	Drainage.
		1908.	*Acres.*			
1	Merriam Park	July 3	80	General	Rolling	Fair.
2	Minneapolis	July 8	36	Dairy	Level	Poor.
3	St. Paul	July 16	12	do	Undulating	Good.
4	do	do	140	General	do	Do.
5	do	July 17	160	do	Irregular	Fair.
6	Gladstone	July 20	13	do	do	Good.
7	do	July 18	75	Dairy	Rolling	Do.
8	Hastings	July 22	120	General	do	Poor.
9	do	do	40	Dairy	Level	Fair.
10	Red Wing	July 23	103½	do	Rolling	Poor.
11	do	July 24	3	General	Irregular	Do.
12	Mankato	July 28	120	Dairy	Level	Do.
13	do	do	28	do	do	Do.
14	do	do	65	do	do	Do.
15	Owatonna	July 30	200	do	do	Good.
16	do	do	136	General	Rolling	Poor.
17	Austin	Aug. 1	640	do	Level	Do.
18	do	do	80	do	do	Fair.
19	Oakland	do	70	do	do	Poor.
20	do	do	235	do	do	Do.
21	Rochester	Aug. 4	160	do	Rolling	Good.
22	South Haven	Aug. 14	150	do	Irregular	Do.
23	St. Cloud	do	248	do	Level	Poor.
24	Sauk Center	Aug. 17	160	Grain	do	Do.
25	Crookston	Sept. 10	160	do	do	Do.
26	Huot	Sept. 11	2	General	Irregular	Fair.
27	Thief River Falls	Sept. 14	145	Grain	Level	Poor.
28	Hallock	Sept. 16	320	General	do	Fair.

BORED WELLS.

1	Chikio	Aug. 10	160	General	Level	Poor.
2	Sauk Center	Aug. 17	120	do	do	Do.
3	Argyle	Sept. 12	160	Grain	do	Fair.
4	do	do	160	do	do	Do.

DRILLED WELLS.

1	Red Wing	July 24	18	Dairy	Irregular	Good.
2	St. Peter	July 27	120	General	Level	Poor.
3	Owatonna	July 30	160	do	do	Fair.
4	do	do	240	do	Rolling	Good.
5	Rochester	Aug. 4	185	do	do	Fair.
6	Alexandria	Aug. 12	141	do	Irregular	Do.
7	do	do	220	do	do	Good.
8	Sauk Center	Aug. 17	330	do	Rolling	Do.
9	Crookston	Sept. 10	240	Grain	Level	Poor.
10	do	do	320	do	do	Do.
11	do	do	160	do	do	Do.
12	Hallock	Sept. 17	480	do	do	Do.
13	Anoka	Sept. 29	230	General	do	Fair.

TABLE I.—*Location, size, and other details of farms in Minnesota on which an investigation of water supplies was made*—Continued.

DRIVEN WELLS.

No.	Location.	Date of visit.	Size.	Kind of farming.	Topography.	
					Character of surface.	Drainage.
		1908.	*Acres.*			
1	Excelsior	June 30	140	General	Irregular	Good.
2	New Brighton	July 3	40	do	Rolling	Fair.
3	St. Louis Park	July 6	60	Dairy	Irregular	Poor.
4	Minneapolis	July 8	180	do	Undulating	Do.
5	Richfield	July 10	90	do	Rolling	Do.
6	Minneapolis	do	230	General	Level	Do.
7	St. Paul	July 15	3	Dairy	do	Do.
8	do	do	10	do	Irregular	Do.
9	do	July 17	80	do	Undulating	Fair.
10	Red Wing	July 23	70	do	do	Do.
11	Morris	Aug. 10	240	General	Level	Do.
12	Henning	Aug. 11	160	do	do	Poor.
13	Crookston	Sept. 11	320	Grain	Irregular	Good.
14	do	do	160	do	Level	Poor.
15	Gladstone	July 20	40	General	do	Good.
16	Anoka	Sept. 29	180	do	do	Do.
17	do	do	145	do	do	Poor.
18	do	do	200	do	do	Fair.
19	do	do	30	do	do	Poor.

SPRINGS.

1	Minneapolis	July 8	35	Dairy	Irregular	Poor.
2	Hallock	Sept. 16	240	General	Undulating	Good.

RIVERS.

1	Huot	Sept. 11	2	General	Irregular	Fair.
2	do	do	1	do	do	Do.
3	Thief River Falls	Sept. 14	77	do	Level	Do.
4	Crookston	Sept. 11	320	Grain	Irregular	Do.

SURFACE RESERVOIRS.

1	Kennedy	Sept. 15	12,000	Grain	Level	Fair.
2	do	do	1,000	do	do	Do.

CISTERNS.

1	Kennedy	Sept. 15	12,000	Grain	Level	Fair.
2	do	do	1,000	do	do	Do.
3	Hallock	Sept. 16	240	General	Undulating	Good.
4	do	do	640	Grain	Irregular	Do.
5	do	Sept. 17	480	do	Level	Poor.

TABLE II.—*Local and structural details concerning the water supplies in Minnesota of which an investigation was made.*

DUG WELLS.

No.	Character of location.	Depth.	Strata.	Casing.	Yield.	Use.	Means of lifting.		Other water on farm.
							Method.	Power.	
		Feet.							
1	Poor	28	Clay, 23 feet; sand, 5 feet	Brick	Insufficient	Drinking and general farm purposes.	Iron pump	Hand	Cistern.
2	do.	15	Soft marsh soil	Wood	Abundant	do.	do.	do.	Ponds.
3	Good	80	Unknown	do.	do.	do.	do.	Windmill	None.
4	Poor	38	Clay, 28 feet; sandy gravel, 10 feet.	do.	Insufficient	do.	Rope and bucket	Hand	Ponds.
5	do.	25	Clay	Tile, 12-inch	Abundant	do.	Wooden pump	do	Cistern.
6	Fair	22	Clay, 9 feet; sand, 13 feet	Wood	do.	do.	Rope and bucket	do	Lake, creek.
7	do.	20	Gravel and clay	do.	do.	do.	Iron pump	Windmill	Ponds.
8	Poor	18	Gravel	Stone	do.	do.	do.	Hand	Cistern.
9	Good	127	Sand and gravel mixed	Tile, 6-inch	do.	do.	do.	Windmill	Do.
10	Poor	15	Black marsh soil	Stone	do.	do.	Rope and bucket	Hand	Creek, springs.
11	do.	10	Surface soil and sand	None	do.	do.	Iron pump	do.	None.
12	do.	25	Sand, clay, and gravel mixed	Stone	do.	do.	do.	do.	Springs, ponds, cistern.
13	do.	12	Clay, 8 feet; gravel, 4 feet	do.	Insufficient	do.	do.	do.	Ponds.
14	do.	27	Surface soil and blue clay	do.	do.	do.	do.	do.	Cistern, ponds.
15	do.	40	Blue clay	do	Abundant	do.	do.	do.	Cistern.
16	do.	30	Unknown	do.	do.	do.	do.	Windmill	Do.
17	do.	60	Yellow clay	Tile	do.	do.	do.	do.	Do.
18	Good	28	Surface soil, 2 feet; sand, 8 feet; hardpan, 4 feet; sand, 6 feet; rock, 8 feet.	Wood	do.	do.	do.	Hand	None.
19	Poor	12	Gravel, blue clay, quicksand	Tile, 2-foot	do.	do.	Wooden pump	do.	Do.
20	do.	30	Surface soil, 3 feet; rest clay	Stone	do.	do.	Iron pump	do.	Do.
21	Fair	30	Surface soil, 3 feet; clay, 10 feet; gravel 17 feet.	do.	do.	do.	do.	do.	Cistern.
22	Poor	14	Clay, 13 feet; gravel and sand, 1 foot.	Wood	do.	do.	do.	do.	Pond.
23	Fair	44	Hardpan, clay, gravel; sand	Brick	do.	do.	do.	do.	None.
24	do.	25	Clay and sand	Wood	do.	do.	Wooden pump	do.	Do.
25	do.	40	Blue clay	do.	do.	do.	do.	do.	Do.
26	Poor	12	Sand, gravel, and clay	do.	do.	do.	Iron pump	do.	River.
27	Fair	13	Blue clay	do.	do.	do.	Rope and bucket	do.	None.
28	Good	18	Loam 2 feet; yellow clay, 5 feet; gravel, sand, and clay, 6 feet; hardpan, 5 feet.	Brick and wood.	Insufficient	do.	do.	do.	River.

BORED WELLS.

1	Poor	55	Clay, 40 feet; sand and gravel, 15 feet.	Wood	Abundant	Drinking and general farm purposes.	Iron pump	Hand	None.
2	do.	27	Clay and sand	None	do.	do.	Wood pump	do.	Do.
3	Fair	10	Blue prairie clay	Tin, 6-inch	Insufficient	Drinking	Rope and bucket	do.	River.
4	do.	13	do.	do.	Abundant	do.	do.	do.	None.

DRILLED WELLS.

No.	Character of location.	Depth.	Strata.	Casing.	Well pit.		Yield.	Use.	Means of lifting.		Other water on farm.
					Depth.	Casing.			Method.	Power.	
		Feet.			*Feet.*						
1	Poor	138	Clay, 17 feet; rest limestone.	Iron pipe, 6-inch, and rock.			Abundant	Drinking and general farm purposes.	Iron pump	Horse	Cisterns.
2	do.	167	Clay and sand	Iron, 2-inch	25	Stone	do.	do.	do.	Windmill	Do.
3	Good	100	Blue clay and rock	Iron pipe, 6-inch.	40	do.	do.	do.	do.	Hand	Well, cistern.
4	Poor	90	Clay, 40 feet; rest gravel, sand	do.	10	Wood	do.	do.	do.	Windmill	Cistern.
5	do.	60	Sand and clay, 30 feet; limestone, 30 feet.	Iron pipe, 3-inch.	30	Stone	do.	do.	do.	do.	Do.
6	Good	80	Gravel, 10 feet; red clay, 10 feet; blue clay, 50 feet; sand and gravel, 10 feet.	do.			do.	do.	do.	Hand	Lake, creek, spring.
7	Poor	60	Clay and sand	Iron			do.	do.	do.	do.	Cistern, ponds.
8	Good	153	Yellow clay, 30 feet; hardpan, 12 feet; sand, 15 feet; clay, 90 feet; sand, 6 feet.	Iron, 4-inch	10	Wood	do.	do.	do.	Windmill	None.
9	do.	200	Blue clay throughout	Iron, 2-inch			do.	do.	do.	do.	Cistern.
10	do.	180	Unknown	do.	14	Iron, 2½-feet.	do.	do.	do.	Hand	None.
11	Fair	203	Blue clay, 20 feet; red clay, 150 feet; mixed sand and clay, 27 feet; rock, 3 feet; sand, 3 feet.	Iron, 2½-inch			do.	do.	do.	do.	Cistern.
12	Poor	75	Hardpan and clay mixture	do.			Insufficient	do.	do.	Windmill	Ponds, cistern.
13	Good	112	Sand and gravel	Iron, 3-inch	10	Wood	Abundant	do.	do.	Gasoline engine.	None.

TABLE II.—*Local and structural details concerning the watersupplies in Minnesota of which an investigation was made*—Continued.

DRIVEN WELLS.

No.	Character of location.	Depth.	Strata.	Casing.	Well pit.		Yield.	Use.	Means of lifting.		Other water on farm.
					Depth.	Casing.			Method.	Power.	
		Feet.			*Feet.*						
1	Good	150	Surface clay, 10 feet; hardpan, 100 feet; gravel, 40 feet.	Iron, 3-inch	6	Brick	Abundant	Drinking and general farm purposes.	Iron pump	Gasoline engine and windmill.	Lake, creek, springs, and cistern.
2	Fair	160	Unknown	Iron pipe, 2-inch.	10	Wood	do	do	do	Windmill	Cistern.
3	Poor	60	do	do	10	do	do	do	do	do	Ponds.
4	do	20	Surface, 3 feet; sand, 17 feet	do	10	do	do	do	do	Gasoline engine.	None.
5	do	50	Unknown	Iron, 1½-inch	10	do	do	do	do	Windmill	Cistern, lake.
6	do	40	Sandy soil	do	10	do	do	do	do	do	Do.
7	do	30	Unknown	do	8	do	do	do	do	do	None.
8	do	119	Sand, 25 feet; rest clay and gravel.	Iron, 2½-inch	7	do	do	do	do	Hand	Do.
9	Good	57	Clay, 50 feet; sand, 7 feet	Iron, 1½-inch	10	do	do	do	do	Windmill	Do.
10	Fair	20	Surface soil, 5 feet; sand, 15 feet.	Iron, 1¼-inch	10	do	do	do	do	Hand	Creek.
11	Good	182	Clay, 70 feet; gravel and sand, 112 feet.	Iron, 2½-inch	12	do	do	do	do	Windmill	Cistern, ponds.
12	Poor	24	Clay, 8 feet; sand, 16 feet	Iron, 2-inch	16	do	do	do	do	do	Cistern.
13	Good	12	Sand, 4 feet; clay, 4 feet; sand, 4 feet.	Iron, 1½-inch			Insufficient	do	Cistern pump	Hand	River.
14	Poor	25	Blue prairie clay	do	20	Wood	do	do	Iron pump	do	Pond.
15	Fair	65	Unknown	do	10	do	Abundant	do	do	do	Lake.
16	do	36	Sand	Iron, 1½-inch	28	Brick	do	do	do	do	River, lake.
17	Poor	40	do	do			do	do	Cistern pump	do	Ponds.
18	do	28	Sand and gravel	do	10	Wood	do	do	Iron pump	do	None.
19	Good	25	do	do	10	do	do	do	do	Windmill	Do.

SPRINGS.

No.	Character of location.	Character of surface around spring.	Spring pit.		Yield.	Use.	Means of lifting.		Other water on farm.
			Depth.	Casing.			Method.	Power.	
			Feet.						
1	Poor	Gravelly soil	10	Wood	Abundant	Drinking and general farm purposes.	Bucket	Hand	None.
2	do	Marshy soil	1	None	do	(Undrinkable)	do	do	Cistern, creek.

RIVERS.

No.	Locality.	Source.	Character of watershed.	Cities or villages on river above this farm.	Use.	Means of lifting.		Other water on farm.
						Method.	Power.	
1	Huot	Red Lake River	Large, flat area	About 6	Drinking and general farm purposes.	Bucket	Hand	Well.
2	do	do	do	do	do	do	do	None.
3	Thief River Falls	do	do	About 4	do	do	do	Do.
4	Crookston	do	do	About 7	do	do	do	Well.

SURFACE RESERVOIRS.

No.	Character of location.	Type.	Source of water.	Shape.	Size.	Casing.	Use.	Means of lifting.		Other water on farm.
								Method.	Power.	
					Feet.					
1	Poor	Dug	Rain	Oval	60 by 40 by 6	Clay	General farm purposes	Iron pump	Windmill	Cistern.
2	do	do	do	Rectangular	60 by 35 by 6	do	do	Wooden pump	Hand	Do.

TABLE II.—*Local and structural details concerning the water supplies in Minnesota of which an investigation was made*—Continued.

CISTERNS.

No.	Character of location.	Type.	Capacity.	Shape.	Casing.	Use.	Means of lifting.		Other water on farm.
							Method.	Power.	
			Barrels.						
1	Fair	Dug	200	Circular, arched top	Brick and cement	Drinking and general farm purposes.	Cistern pump	Hand	Surface reservoir.
2	do	do	150	do	do	do	do	do	Do.
3	Good	do	60	Circular, flat top	Galvanized iron	do	do	do	Spring and creek.
4	Fair	Tanks	200	do	do	do	Pail and rope	do	Creek.
5	Poor	Dug	100	Circular, conical roof	Brick and cement	do	Cistern pump	do	Ponds.

TABLE III.—*Sanitary and epidemiological data concerning the water supplies in Minnesota of which an investigation was made.*

DUG WELLS.

No.	Sanitary aspect of supply.	Sanitary condition of farmhouse and outbuildings.				Milk.		Water-borne diseases.		
		House.	Milk house.	Stables.	Privy.	Sanitary care.	Disposal.	Disease.	Number of cases.	Source of infection.
1	Poor	Fair		Poor	Unprotected vault	Poor	Used on farm	None		
2	do	do		do	do	do	Sold	do		
3	do	do		Fair	do	do	do	Typhoid	1	Probably from St. Paul.
4	do	Poor		Poor	do	do	Used on farm	None		
5	Fair	Good		Good	do	Good	do	do		
6	Poor	Poor		Poor	do	No milk		Typhoid	1	Unknown.
7	Fair	Good	Fair	do	do	Fair	Sold	None		
8	do	do	Good	Good	Protected vault	Good	Cream sold	do		
9	do	do	do	do	do	do	Sold	do		
10	Poor	Good	Poor	Poor	Unprotected vault	Poor	do	do		
11	do	do		Good	do	Fair	Used on farm	do		
12	do	do	Good	do	do	Good	Sold	Typhoid	1	Mankato city water.
13	do	Fair		Poor	do	Poor	do	None		
14	Good	Good	Good	Good	Protected vault	Good	do	do		
15	Fair	do		do	Unprotected vault	do	Sold to creamery	do		
16	Poor	Poor		Poor	do	Poor	do	do		
17	do	Good	Fair	Good	do	Good	do	do		
18	Fair	do		Poor	do	Poor	Butter sold	do		
19	Poor	Poor		do	do	do	Sold	Typhoid	1	Unknown.
20	do	Fair		Good	do	Good	do	None		
21	Good	Good		do	Protected vault	do	do	do		
22	Poor	Poor		Poor	Unprotected vault	Poor	Butter sold	Typhoid	1	Do.
23	do	do		do	do	do	do	do	1	Do.
24	do	do		do	do	do	Sold	do	1	Do.
25	do	do		do	do	do	do	None		
26	do	Good		Fair	do	No milk		Typhoid	1	Red Lake River.
27	do	Poor		do	do	Poor	Butter sold	None		
28	do	do		do	do	do	do	do		

BORED WELLS.

No.	Sanitary aspect of supply.	House.	Milk house.	Stables.	Privy.	Sanitary care.	Disposal.	Disease.	Number of cases.	Source of infection.
1	Fair	Fair		Good	Unprotected vault	Fair	Sold	Typhoid	1	Unknown.
2	Poor	Poor		Poor	do	Poor	do	None		
3	do	Very poor		Very poor	do	do	Used on farm	Typhoid	6	Village of Oslo, Minn.
4	do	do		Good	do	do	do	None		

TABLE III.—*Sanitary and epidemiological data concerning the water supplies in Minnesota of which an investigation was made*—Continued.

DRILLED WELLS.

No.	Sanitary aspect of supply.	Sanitary condition of farmhouse and outbuildings.				Milk.		Water-borne diseases.		
		House.	Milk house.	Stables.	Privy.	Sanitary care.	Disposal.	Disease.	Number of cases.	Source of infection.
1	Fair	Fair		Poor	Unprotected vault	Poor	Sold	None		
2	Poor	Good		Fair	do	Fair	do	Typhoid	3	Unknown.
3	Fair	Fair		do	do	do	do	do	1	Probably from neighbor.
4	Poor	Poor		Good	do	do	do	do	1	Unknown.
5	do	do	Poor	Poor	do	Poor	do	None		
6	Fair	Fair		Fair	do	do	do	do		
7	Poor	Poor		do	do	do	do	Typhoid	8	Do.
8	Good	Good		do	do	Good	do	None		
9	do	do		do	do	Fair	do	do		
10	Poor	Poor		do	do	Poor	Butter sold	Typhoid	2	Do.
11	Fair	do		Poor	do	Fair	do	None		
12	do	do		Good	do	Poor	do	do		
13	Good	Good	Good	do	Protected vault	Good	Cream sold	do		

DRIVEN WELLS.

No.	Sanitary aspect of supply.	House.	Milk house.	Stables.	Privy.	Sanitary care.	Disposal.	Disease.	Number of cases.	Source of infection.
1	Good	Good		Good	Modern	Good	Used on farm	None		
2	Fair	Fair		Poor	Unprotected vault	Poor	do	do		
3	Poor	Poor	Poor	do	do	do	Sold	do		
4	do	do	do	Fair	do	Fair	do	do		
5	do	Fair	do	Poor	do	Poor	do	Typhoid	3	City of Minneapolis.
6	Good	Good		Good	Protected vault	Good	Used on farm	None		
7	Poor	Poor	Fair	Fair	Unprotected vault	Fair	Sold	do		
8	Fair	do	Poor	do	do	Poor	do	do		
9	Good	Good	Good	Poor	do	Good	do	do		
10	do	do		do	do	do	do	do		
11	Fair	do		Good	do	do	Butter sold	Typhoid	1	Unknown.
12	do	do	Good	do	do	do	Cream sold	do	2	Circus at Wadena, Minn.
13	do	do		Poor	do	Fair	Sold	do	2	Red Lake River water.
14	Poor	Poor		do	do	Poor	Butter sold	None		
15	Good	Good		Good	do	Fair	Used on farm	do		
16	Fair	do		Fair	do	Good	Sold	do		
17	Poor	Poor		Poor	do	Poor	Cream sold	Typhoid	1	Rum River water.
18	do	do		do	do	do	do	None		
19	Fair	Good		do	do	Good	Used on farm	do		

SPRINGS.

1	Poor	Good		Fair	Unprotected vault	Fair	Sold	None		
2	do	do		do	do	Good	Butter sold	do		

RIVERS.

1	Poor	Good		Fair	Unprotected vault	No milk		Typhoid	1	Red Lake River.
2	do	Poor		Poor	do	Poor	Used on farm	do	3	Do.
3	do	do		do	do	do	Sold	None		
4	do	Good		do	do	Fair	do	Typhoid	2	Do.

SURFACE RESERVOIRS.

1	Poor	Good	Good	Good	Unprotected vault	Good	Used on farm	None		
2	do	do		do	Protected vault	do	do	do		

CISTERNS.

1	Fair	Good	Good	Good	Protected vault	Good	Used on farm	None		
2	do	do		do	do	do	do	do		
3	Good	do		Fair	Unprotected vault	do	Butter sold	do		
4	Poor	Fair		do	do	Fair	Used on farm	do		
5	do	Poor		Good	do	Poor	do	do		

TABLE IV.—*Analytical data concerning the water supplies in Minnesota of which an examination was made.*

DUG WELLS.

No.	Physical examination.			Chemical examination.									Bacteriological examination.[a]		
	Turbidity.	Color.	Odor at 20° C.	Total hardness.	Alkalinity.	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorin.	Iron.	Free carbonic acid.	Bacteria per cubic centimeter.	Bacillus coli.	
														1 c. c.	100 c. c.
1 [b]	0	0	e 1	520	268	0.056	0.006	0.005	37.00	37.0	Tr.	26	580	—	+
2 [b]	28	140	e 3	930	830	.34	62.00	.007	.20	115.0	8.00	90	2,550	+	+
3 [b]	1	4	ed 2	172	194	.024	.026	.001	1.10	4.0	.90	5	135	—	+
4 [b]	4	24	e 2	64	82	.29	.036	Tr.	.30	31.5	.30	20	7,580	+	+
5 [b]	1	16	e 2	500	438	.14	.014	.002	22.00	66.0	.10	80	785	—	—
6 [b]	1	10	me 1	340	310	.084	.028	.008	6.00	115.0	Tr.	22	......	....	....
7 [b]	0	0	e 1	253	228	.032	.016	Tr.	.50	1.0	.20	5	40	—	—
8 [b]	0	14	e 2	353	279	.25	.056	.012	11.00	30.0	.70	36	1,050	+	+
9 [b]	0	3	e 1	215	210	.024	.012	.00	1.40	.5	.40	......	900	+	+
10 [b]	Tr.	11	de 1	407	350	.21	.048	.02	16.00	51.0	Tr.	51	2,200	+	+
11 [b]	2	22	em 1	310	279	.34	.067	.07	11.00	73.0	.50	45	89	+	+
12 [b]	0	11	e 3	555	411	.088	.016	.002	21.00	74.0	.40	14	2,450	+	+
13 [b]	0	17	d 4	740	613	.26	.83	.016	1.60	103.0	.50	74	1,450	+	+
14 [b]	0	8	e 3	1,000	385	.25	.036	.008	58.00	175.0	Tr.	41	93	+	+
15 [b]	1	11	e 1	1,900	301	.19	.016	.011	145.00	630.0	.60	37	555	+	+
16 [b]	3	16	e 1	500	394	.14	.008	.002	6.00	53.0	.80	24	435	+	+
17 [b]	0	5	e 2	607	316	.12	.03	.005	45.00	48.5	.10	40	400	+	+
18 [b]	......	......	....	378	244	.028	.012	.005	27.00	28.0	.10	20	500	+	+
19 [b]	1	4	e 1	278	254	.032	.012	.001	.80	Tr.	.10	14	600	+	+
20 [b]	3	28	d 4	500	222	.38	.42	.27	52.00	300.0	.40	61	1,000	+	+
21 [b]	4	8	e 2	420	336	.062	.066	.036	14.00	32.0	.30	35	210	+	+
22 [c]	0	0	v 3	429	228	.11	.04	.045	30.00	45.0	.05	28	325	+	+
23 [b]	0	Tr.	v 1	383	216	.046	.012	.001	5.00	9.0	.40	100	24,300	+	+
24 [c]	5	35	v 2	182	378	.192	.006	.00	.00	12.0	1.60	23	1,635	+	+
25 [c]	5	10	v 2	830	688	.054	.012	.08	20.00	40.0	.00	51	23,400	+	+
26 [c]	15	40	v 2	450	374	.474	.154	.07	35.00	80.0	Tr.	36	2,000	+	+
27 [c]	15	10	d 3	443	400	.458	.120	.010	.00	10.0	Tr.	51	10,000	+	+
28 [c]	5	20	e 2	895	540	.330	.072	.025	3.50	185.0	.40	20	2,600	+	+

BORED WELLS.

No.	Turbidity.	Color.	Odor at 20° C.	Total hardness.	Alkalinity.	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorin.	Iron.	Free carbonic acid.	Bacteria per cubic centimeter.	Bacillus coli, 1 c. c.	Bacillus coli, 100 c. c.
1 [b]	3	12	d 4	3,800	545	0.24	0.092	0.05	1.20	11.0	0.50	39	570	+	+
2 [c]	15	20	v 1	265	480	.076	.120	Tr.	.00	.8	2.00	58	495	+	+
3 [c]	400	10	e 3	760	540	.256	3.380	.02	.00	85.0	1.20	50	10,000	—	+
4 [c]	20	0	e 2	479	312	.710	.200	.003	Tr.	110.0	.00	25	10,000	+	+
5	......	......	....	......	......	......	......	......	......	......	......	......	130	+	+
6	......	......	....	......	......	......	......	......	......	......	......	......	380	+	+

DRILLED WELLS.

No.	Turbidity.	Color.	Odor at 20° C.	Total hardness.	Alkalinity.	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorin.	Iron.	Free carbonic acid.	Bacteria per cubic centimeter.	Bacillus coli, 1 c. c.	Bacillus coli, 100 c. c.
1 [b]	4	6	e 1	218	221	0.01	0.012	0.000	0.50	1.5	0.50	7	755	—	+
2 [b]	0	7	e 2	800	322	1.20	.01	.007	28.00	63.0	Tr.	19	785	+	+
3 [b]	Tr.	4	e 1	470	270	.08	.026	.001	10.00	102.0	.10	10	220	+	+
4 [b]	21	10	ed 3	338	388	.07	.15	.015	.15	.5	3.10	26	705	—	+
5 [b]	2	0	p 4	393	306	.056	Tr.	.002	9.00	9.5	.10	15	330	+	+
6 [b]	1	12	m 2	610	394	.08	.086	.028	6.20	33.5	.20	26	2,210	+	+
7 [b]	2	11	m 2	785	354	.092	.068	.45	28.00	77.0	......	35	760	+	+
8 [c]	300	5	e 1	286	460	.052	.814	Tr.	.00	8.0	25.00	98	150	—	—
9 [c]	5	20	e 1	150	268	.432	1.374	Tr.	.00	100.0	1.20	28	17	—	—
10 [c]	0	10	v 2	575	452	.152	.084	.10	15.00	65.0	Tr.	70	540	—	—
11 [c]	0	10	e 1	130	224	.086	.700	.004	.30	115.0	Tr.	9	255	—	—
12 [c]	50	25	e 1	550	304	.306	.630	.100	3.50	655.0	2.80	40	850	+	+
13 [c]	25	20	e 1	205	200	.060	.030	Tr.	.00	2.0	2.80	25	10	—	—

[a] Bacteriological examination by Dr. A. J. Chesley.
[b] Chemical and physical examinations by Mr. M. G. Roberts.
[c] Chemical and physical examinations by Mr. H. A. Whittaker.

TABLE IV.—*Analytical data concerning the water supplies in Minnesota of which an examination was made.*—Continued.

DRIVEN WELLS.

No.	Physical examination.			Chemical examination.									Bacteriological examination.[a]		
	Turbidity.	Color.	Odor at 20° C.	Total hardness.	Alkalinity.	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorin.	Iron.	Free carbonic acid.	Bacteria per cubic centimeter.	Bacillus coli.	
														1 c. c.	100 c. c.
1 [b]	......	32	m 2	303	338	0.038	0.072	0.005	0.02	2.5	1.90	29	160	+	+
	......	8	md 2	303	341	.18	.10	.003	.02	2.5	6.40	33	80,000	+	+
2 [b]	2	22	m 2	250	280	.02	.44	.00	.15	1.0	1.30	3	256	–	+
3 [b]	0	0	e 2	310	246	.026	.04	.003	3.80	4.0	.20	15	350	–	–
4 [b]	0	0	e 1	560	319	.072	.21	.26	13.00	19.0	.25	24	1,550	+	+
5 [b]	18	95	e 1	435	248	.37	.31	.025	2.40	4.0	6.80	20	29	–	–
6 [b]	6	48	e 2	445	234	.028	.048	Tr.	Tr.	3.0	2.20	13	58	–	–
7 [b]	0	0	e 2	200	236	.02	.004	.00	2.30	3.5	.20	11	170	–	+
8 [b]	12	30	em 1	220	218	.04	.01	.003	4.40	6.0	21.00	10	550	–	+
9 [b]	0	0	e 1	190	248	.026	.003	.00	.22	Tr.	Tr.	7	33	–	–
10 [b]	2	7	e 2	281	260	.010	.002	Tr.	.25	Tr.	.40	35	25	–	–
11 [b]	200	4	d 3	2,000	363	.084	1.50	.001	Tr.	3.0	62.00	49	10	–	–
12 [b]	3	10	e 1	253	193	.026	.004	Tr.	5.40	3.0	.50	6	10	–	–
13 [c]	0	30	e 2	500	412	.444	.022	Tr.	2.50	5.0	.00	45	1,250	–	+
14 [c]	0	120	d 2	770	828	2.340	13.400	.220	35.00	165.0	1.20	90	1,153	+	+
15 [b]	3	14	md 2	......	175	.024	.006	Tr.	3.40	2.0	1.40	6	65	–	–
16 [c]	0	0	e 1	300	200	.060	.022	.001	30.00	22.0	.10	11	45	–	–
17 [c]	0	0	v 2	620	260	.036	.030	.020	35.00	14.0	Tr.	14	25	–	+
18 [c]	0	0	v 2	190	180	.084	1.260	.002	.30	2.0	Tr.	21	10	–	–
19 [c]	15	15	v 1	243	200	.068	.240	Tr.	.00	2.0	1.80	18	10	–	–
SPRINGS.															
1 [b]	0	0	m 2	179	176	0.048	0.024	0.009	6.00	3.5	0.05	3	2,200	+	+
2 [c]	5	15	v 1	1,110	328	.238	1.050	.033	.00	2,350.0	1.60	52	1,000	+	+
RIVERS.															
1 [c]	10	50	v 3	176	140	0.580	0.026	Tr.	1.00	5.0	Tr.	3	1,216	+	+
2 [c]	10	50	v 3	176	140	.580	.026	Tr.	1.00	5.0	Tr.	3	1,216	+	+
3 [c]	15	25	v 2	176	146	1.084	.390	0.00	0.00	5.0	Tr.	8	10,000	+	+
SURFACE RESERVOIRS.															
1 [c]	160	40	v 2	1,530	112	3.014	0.860	Tr.	0.00	4,100.0	8.00	62	2,000	+	+
2 [c]	5	30	v 3	457	176	1.346	1.410	0.080	.00	505.0	.00	23	890	+	+
CISTERNS.															
1 [c]	0	30	v 1	22	36	0.235	0.260	0.007	0.30	5.0	0.00	3	1,000	+	+
2 [c]	5	30	v 1	32	32	.390	.623	.00	.00	10.0	.00	11	1,000	+	+
3 [c]	5	20	v 1	30	8	.214	.446	Tr.	.00	10.0	.40	5	1,000	+	+
4 [c]	5	55	v 2	40	12	.504	.490	.005	.00	50.0	.00	13	80,000	+	+
5 [c]	5	30	v 2	64	36	.560	.042	.00	.00	80.0	Tr.	7	1,000	+	+

[a] Bacteriological examination by Dr. A. J. Chesley.
[b] Chemical and physical examinations by Mr. M. G. Roberts.
[c] Chemical and physical examinations by Mr. H. A. Whittaker.

A review of the foregoing data shows that of the 79 supplies examined 20 furnished water of a satisfactory quality, while 59 were more or less seriously polluted. It must be remembered, however, that, other conditions being similar, bad supplies are of greater interest to the sanitary investigator and are selected for study, as it is these supplies which indicate the dangers to be avoided. Therefore, the percentage of unsanitary supplies is much larger than would be found if examination had been made of all the rural water supplies of any large area. The actual proportion of polluted supplies in rural districts may at present be assumed to be about 35 per cent.[a]

The distinction between good and bad supplies is of course an arbitrary one. In accordance with the modern ideas upon this subject the greatest dependence is placed upon personal inspection of the environment of any supply in question,[b] the bacteriological data being next in importance.

Interpreted in the light of the field observations the bacteriological examination gives the best evidence of actual pollution, in spite of the difficulty of determining the significance of the so-called sewage organism, *Bacillus coli*. The more or less ubiquitous character of this bacillus[c] does not, however, entirely destroy its value as an indicator of pollution. It must be remembered that typhoid fever, popularly the most dreaded disease, is by no means the only one that the water sanitarian is called upon to prevent. The great decrease in death rate, exclusive of deaths from typhoid, which follows the installation of a bacteriologically pure water supply[d] shows the necessity for extending the idea of a polluted water beyond the mere possibility of its serving as the carrier of typhoid bacilli. With the assumption, therefore, that minor and indefinite or undescribed intestinal disturbances play a considerable part in the death rate due to polluted water, that much-discussed organism *Bacillus coli* may still fairly be taken as representing by its presence a more or less objectionable pollution, as it is essentially an intestinal inhabitant, whether of human or other animal origin. The degree of pollution must be determined from the total count of bacteria, supplemented by the chemical analyses, and from the field observations.

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[a] Kellerman, K. F., and Beckwith, T. D. Bacteria of the Dairy Wells in the Vicinity of Washington, D. C., and Their Possible Relation to Typhoid Fever at Washington. Engineering News, vol. 57, No. 6, p. 152. 1907.

[b] Leighton, M. O. The Futility of a Sanitary Water Analysis as a Test of Potability. Biological Studies by the Pupils of W. T. Sedgwick, pp. 36–53. Boston, 1906.

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[c] Dyar, H. G., and Keith, S. C. Notes on Normal Intestinal Bacilli of the Horse and of Certain Other Domestic Animals. Technology Quarterly, vol. 6, pp. 256–257. 1893.

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[d] Hazen, Allen. Purification of Water in America. Transactions of the American Society of Civil Engineers, vol. 54, part D, pp. 131–154. 1905.

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RURAL TYPHOID FEVER.

The vital statistics of the country are even less satisfactory than those of the city, and in spite of the emphasis that has recently been given to the importance of rural typhoid[a] it is at the present time impossible to determine whether typhoid fever is essentially an urban disease, as has been generally supposed, occasionally transmitted into other districts, or whether rural typhoid exists as such, independent of city infection. In the Minnesota studies the origin of many cases was untraceable, perhaps because typhoid fever is a disease carelessly or irregularly reported to the State Board of Health by the attending physicians, and for practical purposes it is necessary for the present to assume that in any rural district typhoid fever may suddenly develop.

During this investigation 23 of the farms examined showed a record of typhoid fever. On 11 of these farms it was found impossible to locate the source of infection, on 2 possible sources were determined, and on 10 farms the data seemed to locate definitely the source of infection. The water supplies furnishing data which more or less definitely located the source of typhoid infection will be briefly noted.

Farm No. 12, under dug well type. One case during 1908, a boy 15 years of age, taken sick July 18. For some weeks before the boy became ill the city of Mankato, Minn., had been suffering from a severe typhoid epidemic, due to an infected city water supply.[b] The boy, who delivered milk in the city, drank water from the city supply on a number of occasions before his illness. He was immediately removed to the city hospital and no other cases developed on the farm.

Farm No. 3 under bored well type. Six cases during the spring of 1908. The first case was brought from Oslo, Minn., where the patient had been employed as a servant in one of the hotels. The secondary cases may have been due to contact or to water pollution.

Farm No. 5 under driven well type. Three cases during 1907; apparently infected in Minneapolis.

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[a] Whipple, G. C. Typhoid Fever, pp. 112–114. New York, 1908.

[b] Established by extensive investigations made by the Minnesota State Board of Health.

Farm No. 12 under driven well type. Two cases during 1908; the first, a girl 16 years old, was taken sick July 14, and the second, a boy 14 years old, was taken sick July 25. Both of the infected people attended a circus at Wadena, Minn., June 27, on which occasion they drank city water, water on the railroad train, and circus lemonade. On July 10 they attended a second circus at Henning and drank water from several sources. The data collected indicate quite clearly that the disease was contracted during attendance at the Wadena circus, June 27.

Farm No. 17 under driven well type. One case during 1907, a man taken sick October 10. September 19 to 21 he had attended a street fair at Anoka, Minn., and drank water from the city drinking fountain. Several cases of typhoid were present in the city of Anoka and were supposed to have been infected by the city supply.[a]

Farm No. 2 under drilled well type. Three cases during 1908; the first two, a man and a woman, taken sick July 7, the third, a woman, taken sick July 17. The well on this place is badly located and receives surface wash from the entire yard. The privy is so located that during heavy rains, which occurred at the period of the year previous to the infection, the surface wash from that direction reaches the well.

RURAL TYPHOID EPIDEMIC FROM THE RED LAKE RIVER.

A small rural epidemic occurred during the investigation in the Red River Valley and included three farms in a sparsely populated region.

Farm No. 13 under driven well type and farm No. 4 under "Rivers." Two cases in 1908; a girl 19 years old, taken sick February 10, and a boy 13 years old, taken sick March 10. The girl had not been away from the farm for at least six weeks preceding her illness and no other cases of typhoid were present in the community. During the winter season until February 25 the water supply was the Red Lake River, which flows near the house. At a point called Huot, several miles up the Red Lake River from this farm (see farms No. 2 under "Rivers" and No. 26 under "Dug wells"), four cases of typhoid occurred during the spring season; the first, a boy 10 years old, taken sick February 15; the second, a man 40 years old, taken sick February 28; the third, a boy 7 years old, taken sick April 19. None of these patients had visited any other district before or after their infection. The other case of this infected group was a man 38 years old who was taken sick April 1. (See farms No. 1 under "Rivers" and No. 26 under "Dug wells.") From February 28 until the date of illness he had remained constantly with his brother. (See farm No. 2 under

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[a] Data furnished by the Minnesota State Board of Health.

"Rivers.") He drank Red Lake River water from November 15 until the date of his illness. This case may be one of contact or of direct infection from the original source, the Red Lake River.

The cities contributing sewage or drainage above the point of infection are St. Hilaire, Red Lake Falls, and Thief River Falls. During the winter season there are lumber camps scattered along the Red Lake River beyond Thief River Falls, and these also might play some part in the pollution. The river also flows through a part of the Red Lake Indian Reservation.

SUMMARY AND CONCLUSIONS.

(1) Both farm and city are suffering from the careless management of rural sanitation.

(2) Previous investigations of rural water supplies have been more or less unsatisfactory, due either to the local or fragmentary character of the investigations or to the use of a single method in studying the supplies in question.

(3) Exhaustive data upon 79 carefully selected and typical rural water supplies show that 20 were good and, usually because of careless or ignorant management, that 59 were polluted.

(4) Of the polluted wells, 11 are so located that even extreme care would not make them safe; 10 are poorly located, but improvements in the protection from surface wash and infiltration would make them safe; 25 are bad only because of poor surface protection and could easily be made safe; 1 is polluted from unknown, probably distant, sources. One spring supply is polluted because of poor surface protection and could easily be made safe. The rivers, surface reservoirs, and cisterns are polluted, and it is doubtful whether satisfactory supplies can be secured for farm use from such sources. Where their use is necessary, water for drinking should be boiled or otherwise disinfected.

(5) During this investigation 23 of the farms examined showed a record of typhoid fever. On 11 of these farms it was found impossible to locate the source of infection, on 2 farms possible sources were determined, while on 10 the data seemed to locate definitely the source of infection. The water supplies upon 5 of these farms were not polluted and the infection was traceable to outside sources; the water supplies of the remaining 18 farms were polluted.

(6) The protection of farm supplies by common-sense methods obvious to anyone who will try to discover the dangers incident to his own water supply would render safe the majority of the farm supplies which are now polluted. Exhaustive studies of rural conditions at the present time, therefore, are warranted only in connection with epidemiological studies.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 155.

B. T. GALLOWAY, *Chief of Bureau.*

THE CONTROL OF BLACK-ROT OF THE GRAPE.

BY

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AND

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Scientific Assistants, Fruit Disease Investigations.

Issued August 30, 1909.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., May 10, 1909.

Sir: I have the honor to transmit herewith a paper entitled "The Control of Black-Rot of the Grape," a report of three seasons' spraying experiments by Dr. C. L. Shear, Pathologist, and Messrs. George F. Miles and Lon A. Hawkins, Scientific Assistants, of this Bureau, and recommend its publication as Bulletin No. 155 of the series of the Bureau of Plant Industry.

The paper contains the results of grape spraying experiments conducted in New York, New Jersey, Pennsylvania, and Michigan. The work shows conclusively that the most serious epidemics of black-rot, such as prevailed in Michigan, can be satisfactorily controlled by thorough and proper methods of spraying. It also indicates that smaller quantities of copper sulphate and lime than have heretofore been thought necessary in the preparation of Bordeaux mixture will give just as satisfactory results as the stronger mixtures.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—472.

THE CONTROL OF BLACK-ROT OF THE GRAPE.

INTRODUCTION.

Ever since the beginning of commercial grape growing in the eastern United States, black-rot has been one of the most serious enemies with which vineyardists have had to contend. It is now more than twenty years since the introduction of spraying for grape diseases in this country. During this period much work upon this subject has been done by the Department of Agriculture and the State agricultural experiment stations, and as a result many improvements have been made in the formulas and the preparation of fungicides, and in the methods of applying them. These have resulted in much more efficient work and also in a reduction of the cost of the operations.

The continued success of commercial grape growing in any of the humid portions of this country has heretofore largely depended upon the successful control of the fungous diseases. Virginia, North Carolina, Florida, southern Ohio, Missouri, and New Jersey have each during the last seventy-five years been important grape-growing centers. Grape growing has arisen and flourished in various parts of the eastern United States only to decline and be largely abandoned after having passed through a severe epidemic or series of epidemics of black-rot. Notwithstanding the success which has been attained in recent years by the Department of Agriculture and the agricultural experiment stations, these outbreaks are not usually satisfactorily controlled by the growers. Black-rot still causes heavy losses and continues to threaten the industry in various localities.

Unsatisfactory results from spraying are according to our observations most generally due to lack of thoroughness in the application of the fungicide. In many cases improperly prepared mixtures and poor apparatus are also important causes of failure. Without an opportunity to observe in actual operation the various processes connected with the proper preparation and application of fungicides, it seems to be difficult for many persons to carry out satisfactorily the most successful methods of spraying. One who undertakes spraying for the first time and does the work, as he thinks, in accordance with the best method and yet only meets with indifferent success or failure is quite likely to lose confidence in the treatment or to condemn it entirely. It is therefore very important that the subject should be thoroughly understood and the work properly carried out from the beginning.

Owing to the failure of many vineyardists in their efforts to prevent black-rot, a series of investigations was undertaken to demonstrate the efficiency of the best methods at present practiced and at the same time to improve, if possible, both methods and mixtures and also to secure more accurate knowledge of the life history and habits of the black-rot fungus and of the other parasitic fungi which are more or less destructive to the grape. This work was commenced in the spring of 1906 at North East, Pa. In 1907 it was extended to central New York and Michigan, and the past season, 1908, it has been carried on in Pennsylvania, New York, Michigan, and New Jersey. In order to determine the various factors influencing the black-rot fungus and its successful control, as well as the relative importance and relation of these factors, it seemed necessary to carry on the work at different points which should represent different soils and climatic conditions as well as with different varieties of grapes and methods of training and cultivation.

THE CAUSE OF BLACK-ROT.

Black-rot is caused by a parasitic fungus known botanically as *Guignardia bidwellii*. It is a vegetable organism which reproduces and spreads by means of minute microscopic bodies called spores. These are borne in small black globose bodies which may be seen covering the surface of mummied grapes which have been destroyed by rot. This parasite produces two well-known spore forms, as shown in figure 1. These are somewhat similar in appearance and differ chiefly in the way in which they are produced. The so-called summer spores are borne on the ends of small, slender threads, and when mature are set free and escape in white tendril-like masses through an opening at the apex of the minute spore case. This form usually occurs first upon the grape leaves in the shape of small black pustules scattered over a reddish or whitish more or less circular dead spot. If a little later the weather conditions are favorable the fungus may be found attacking the flower buds or very young fruit, which may be destroyed at any time from the setting of the fruit to near the maturity of the berries. Fruit which is attacked when very young turns black and soon drops off, and this stage of the disease is frequently called blight or blast. Later, when the berries are one-third grown or larger, the disease usually starts in the form of a sordid white spot, which increases more or less rapidly in size until the whole berry is affected and begins to shrivel, and sooner or later becomes covered with the minute black pustules of the black-rot fungus. What is frequently called "bird's-eye," or anthracnose, by growers in New York and Pennsylvania is a condition of development due to the black-rot fungus and is not the true anthracnose. A form of the disease in which the berries rot rapidly and become soft is sometimes called soft-rot. Besides the leaves and fruit the fungus also attacks the young shoots, producing numerous small, reddish brown spots.

During the autumn and winter the fungus continues to grow when conditions are favorable, and the second spore form is produced. These spores, sometimes called winter spores, grow inside of a minute sac and are usually eight in number, as shown in figure 1, *c*. These sacs with their spores are produced inside of small black pustules very closely resembling those which contain the free summer spores. There are several points in regard to the life history of this fungus and the various means by which infection is accomplished which are not yet thoroughly understood, and much more work is needed to verify and extend our knowledge of these matters.

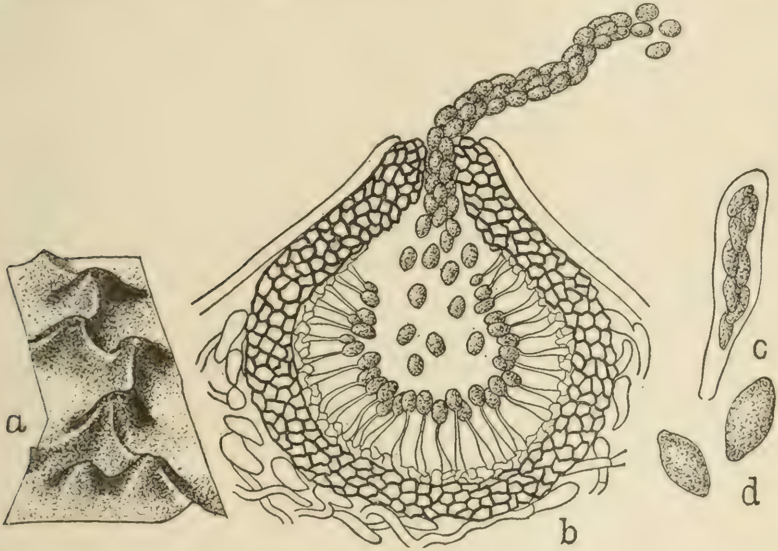

FIG. 1.—The black-rot fungus (*Guignardia bidwellii*): *a*, A portion of an affected grape, showing the pustules in which the spores are produced (slightly magnified); *b*, a section of one of these pustules very highly magnified, showing the manner in which the summer spores are produced and discharged; *c*, a sac containing winter spores; *d*, single winter spores very highly magnified.

The first infection of the young foliage and buds in the spring is believed to come from the winter spores which are expelled from the mature fruiting pustules of the fungus and are driven by the wind and rain to the young growing parts of the vine. These spores are usually produced upon the old black-rot mummies from spring until late summer whenever sufficient moisture in the form of rain, fog, or dew is present, and they are regarded as a source of infection during that period. The fungus having gained entrance to the leaves, shoots, or young fruit may immediately begin to produce the summer spores which, when discharged and distributed to the fruit and other parts of the plant, may produce further infection and disease. So far as known at present, after the fungus has gained entrance to the tissue of the leaf or has gotten beneath the skin of the berry its further development under favorable climatic conditions can not be prevented by any practical means; hence, all measures to be undertaken against the disease must be directed toward preventing the fungus from gaining entrance to the plant and reproducing itself. The winter spores borne upon the old mummied grapes are regarded as one of the chief sources of early infection, and any practical means of destroying or preventing the distribution of these spores should tend to restrict the spread of the disease. That this is a matter of great importance has been shown by observations made during the course of this work. Vines located near unsprayed plants in an adjoining vineyard which had an abundance of black-rot mummies were much more seriously affected by the rot than those which were farther removed from this source of infection. Where black-rot is serious it will be found profitable, in the opinion of the writers, to destroy or bury all the old mummied grapes in the vineyard. At the time of pruning, all diseased grapes which are still hanging on the vines should be picked and burned or buried deeply and all the mummies on the ground should be either raked up and burned or else buried deeply by plowing. All the prunings from the vineyard should also be destroyed by burning, as the diseased shoots may produce spores of the black-rot fungus.

Having destroyed or removed as far as practicable the source of infection, the next step is to protect the entire plant as nearly as possible from any spores which may reach it, and this is accomplished in practice by spraying with fungicides. These are composed of chemicals which prevent the germination of the fungous spores with which they come in contact. If, therefore, every portion of a grape plant which may form a point of entrance for the fungus is covered with a film of a fungicide like Bordeaux mixture, any spores which may be present at the time the fungicide is applied or any others which may fall upon the plant before the fungicide has been washed off or removed in any way will be destroyed; hence, what is desired in spraying is to cover the plant as nearly as possible with a very thin film of the fungicide and to keep the plant covered during the portion of the season when infection is likely to occur. In order to accomplish this, the very best nozzles and spraying machines must be used and handled by persons who are very careful and thorough in their work. The fungicides used must be carefully prepared according to the best methods and formulas.

The technical investigations of the various problems have not yet been completed; therefore, only the results of immediate practical importance are reported at this time.

THE FUNGICIDES USED.

In the trial of various fungicides several purposes were kept in view: First, the efficiency of the fungicide; second, its economy as determined by the cost of material and its preparation and application; and, third, in the case of nonstaining applications, efficiency as compared with cost and injury to the fruit by staining. Following are the formulas of the different preparations used:

Bordeaux mixture.—Commercial copper sulphate, fresh stone lime, and water, in the order given, were prepared according to the following formulas:[a]

6–3–50 (For first application only, before buds burst.)
5–5–50
5–4–50
5–3–50
4–4–50
4–3–50
4–2–50
3–3–50
3–2–50
3–1–50 (For final application only.)

According to recent investigations of the chemistry of Bordeaux mixture made by Pickering,[b] the addition of a greater quantity of lime than is sufficient to neutralize the copper sulphate and render it slightly alkaline interferes with the efficiency of the mixture as a fungicide. He maintains that any excess of lime must first be oxidized and disappear before the copper can be acted upon and become effective; thus, any excess of lime tends to retard the fungicidal action of the mixture and should never be added except for the purpose of protecting foliage which would be injured by mixtures not containing an excess of lime. Experiments made by Kelhofer[c] to determine the difference in the adhesive qualities of mixtures made with different quantities of lime gave the best results when two parts by weight of copper sulphate were used with but one part of lime. Such a mixture would be represented by our 4–2–50 formula. To the weaker solutions of Bordeaux mixture resin-fishoil soap was added for one or more of the applications to improve their adhesive qualities.

Burgundy mixture.—Three formulas were used: (1) Composed of 1½ pounds of copper sulphate and 2 pounds of sodium carbonate to 50 gallons of water; (2) composed of 1 pound of copper sulphate and $1\frac{1}{2}$ pounds of sodium carbonate to 50 gallons of water; (3) composed of $1\frac{1}{4}$ pounds of copper sulphate and $1\frac{5}{8}$ pounds of sodium carbonate to 50 gallons of water. The ingredients were dissolved separately and mixed in a dilute condition.

---

[a] Whenever formulas for Bordeaux mixture are given in this paper the first number indicates the number of pounds of copper sulphate used; the second, the number of pounds of stone lime; and the last, the number of gallons of water.

[b] Pickering, Spencer. Interaction of Metallic Sulphates and Caustic Alkalis. Proc. Chem. Soc., vol. 23, p. 261. London, 1907.

[c] Kelhofer, W. Ueber einige Gesichtpunkt bei die Herstellung der Bordeauxbrühe. Inter. Phytopath. Dienst., vol. 1, p. 65. 1908.

Perdeux mixture.—This is a preparation which was found in use in France and was very highly recommended. An analysis of a sample by the Bureau of Chemistry showed that it consisted of a mixture of pulverized copper sulphate and sodium carbonate, being essentially a form of Burgundy mixture. Preparing this in about the same proportions as indicated by the analysis, we have the following formula: 5 pounds of copper sulphate, 2 pounds of sodium carbonate, and 50 gallons of water. As might be expected from comparison with the formulas of the same constituents used in the Burgundy mixture, it was found impracticable to use this mixture on account of its severe injury to the foliage.

Sodium benzoate Bordeaux mixtures.—These mixtures were prepared as follows: (1) 2 pounds of copper sulphate, 1 pound of lime, and 1 pound of sodium benzoate to 50 gallons of water; (2) 1 pound of copper sulphate, 1 pound of lime, and one-half pound of sodium benzoate to 50 gallons of water. The ingredients were dissolved separately and mixed in a dilute condition.

Copper borate mixture.—Mixtures of this fungicide were prepared according to the following formulas: (1) $1\frac{1}{2}$ pounds of copper sulphate, 2 pounds of borax, 50 gallons of water; (2) $1\frac{1}{4}$ pounds of copper sulphate, 2 pounds of borax, 50 gallons of water; (3) 1 pound of copper sulphate, 2 pounds of borax, 50 gallons of water. Resin-fishoil soap was also added to most of these mixtures to improve their adhesive qualities and to determine the benefit to be derived from this source.

Ammoniacal copper carbonate.—This spray was prepared with 5 ounces of copper carbonate and 3 pints of ammonia to 50 gallons of water.

Copper chlorid mixture.—Prepared according to the following formula: 4 ounces of copper sulphate, 2 ounces of calcium chlorid, 50 gallons of water, with the addition of 1 pound of resin-fishoil soap.

Normal copper acetate solution.[a]—Prepared with one-half pound of normal copper acetate to 50 gallons of water.

Neutral copper acetate solution.[b]—Prepared by dissolving 1 pound of neutral copper acetate in 50 gallons of water.

---

[a] The copper acetate used in some of the experiments was supplied under the name of normal copper acetate.

[b] In the work of 1908 all material used was purchased from the same source and labeled "neutral copper acetate." This form of copper acetate, the writers believe, is least apt to injure foliage and gives very good results as a fungicide.

Basic copper acetate (verdigris solution).—Prepared by dissolving 5 ounces of basic copper acetate in 50 gallons of water.

Copper sulphate solution.—Prepared with 3 pounds of copper sulphate to 50 gallons of water. Used as a dormant application only.

Self-boiled lime-sulphur.—(1) Prepared by mixing 8 pounds of flowers of sulphur with 15 pounds of stone lime, with the addition of hot water, diluting the whole to 50 gallons; also (2) 10 pounds of sulphur to 15 pounds of lime, with the same quantity of water.

"*A*" *brand concentrated lime-sulphur.*[a]—This mixture was used in two strengths: (1) 1 gallon of the concentrated preparation added to 50 gallons of water, and (2) 1 gallon added to 75 gallons of water.

"*B*" *brand concentrated lime-sulphur.*[a]—Prepared with 1 gallon of the concentrated solution added to 50 gallons of water.

METHOD OF MIXING.

The writers have practiced in all cases the method of preparing Bordeaux mixture which has heretofore been described in many of the publications of the Department of Agriculture and which is given in Farmers' Bulletin No. 284 in connection with the treatment of fungous diseases of the grape.

The copper sulphate and the lime are each diluted separately and thoroughly mixed together in a dilute form. Modifications of this method are said by some American and European pathologists to give equally good results, but the writers have not tested them as yet sufficiently to express an opinion.

WORK IN PENNSYLVANIA.

EXPERIMENTS IN 1906.

For several years preceding 1906, the time this work was commenced, an epidemic of black-rot had prevailed in the grape belt in northwestern Pennsylvania, the center of which is North East. The work at this point was undertaken through an understanding with the Pennsylvania State College Agricultural Experiment Station and at the earnest solicitation of the grape growers.

The vineyard selected for the work consisted of 12 acres of Concord vines about 17 years old. The plots were 1.6 acres each and consisted of 10 rows, running east and west. There had been some loss from black-rot the preceding year, but it was not severe. The mixture used just before the leaf buds had opened was 6–4–50 Bordeaux, applied on May 5. Other fungicides used during the season were 5–5–50 Bordeaux mixture, Perdeux mixture,[b] Burgundy mixture and 1 pound of resin-fishoil soap, and ammoniacal copper carbonate solution. Lead arsenate was also added for rootworms which were affecting the vineyard.

---

[a] These are commercial preparations generally obtainable.

[b] The composition of these mixtures is given on pages 11–13.

Seven applications of Bordeaux mixture were made on one plot, six on another, and four on another. Five applications of the Burgundy mixture and the ammoniacal copper carbonate solution were also tried.

The season was rather dry and unfavorable for the development of black-rot, so that there was no appreciable loss from this cause on the unsprayed check plot. There was, however, some injury from powdery mildew, which began to attack the foliage early in July, so that the principal benefit derived from the spraying was apparently due to the prevention of injury from this mildew. There was so little difference in the fruit of the different plots at picking time that it did not seem advisable to attempt to pick and sort separately the crop from each of the plots.

Plot 5, which had received four applications of 5–5–50 Bordeaux mixture, was picked and graded separately and compared with the fruit picked from the check plot. The check plot produced 2,195 4-pound baskets, and the sprayed plot 2,170 4-pound baskets. The principal profit apparently derived from spraying is indicated by the small quantity of culls or wine grapes present. On the check plot 15 per cent of the fruit consisted of culls, while on the sprayed plot there were only 8 per cent of culls. The fruit on the sprayed plot was also firmer and of much better keeping quality, according to the report of the buyer who packed and handled it. It will be noted, however, that on the check plot there were 25 baskets of fruit more than were on the sprayed plot. This was perhaps due to the fact that the check plot happened to contain some more vigorous and productive vines than the sprayed plot. This is always a source of some error in computing results. Even where the vines are of the same number and the same age there will always be some which are naturally more productive than others. The spraying outfit used in this work was a geared traction sprayer.

The following table shows the treatment of sprayed plot 5:

TABLE I.—*Treatment given plot 5 at North East, Pa., in 1906.*

Date of spraying.	Fungicide used.	Stage of growth.
June 8	5–5–50 Bordeaux mixture	Just before blooming.
June 26	5–5–50 Bordeaux mixture plus lead arsenate	Berries all set.
July 9	5–5–50 Bordeaux mixture plus lead arsenate and soap.	Berries size of peas.
July 25	¾ pound copper sulphate to 50 gallons of water	Berries three-fourths grown.

EXPERIMENTS IN 1907.

The work was continued in the same vineyard in 1907. The following fungicides were used: 5–5–50 Bordeaux mixture; 4–4–50 Bordeaux mixture; Burgundy mixture No. 1, plus 1 pound of resin-fishoil soap; Burgundy mixture No. 2, plus 1 pound of resin-fishoil soap; copper borate mixture No. 1; basic copper acetate solution, 5 ounces to 50 gallons of water; and copper chlorid mixture with 1 pound of resin-fishoil soap.

The first applications were made with a gasoline-engine outfit, as illustrated in figure 2. Subsequent applications were made with geared traction sprayers.

The weather conditions during 1907 were also dry and unfavorable for the development of black-rot, so that there was no loss from this cause on the check plot. There was, however, some injury from powdery mildew, as in 1906.

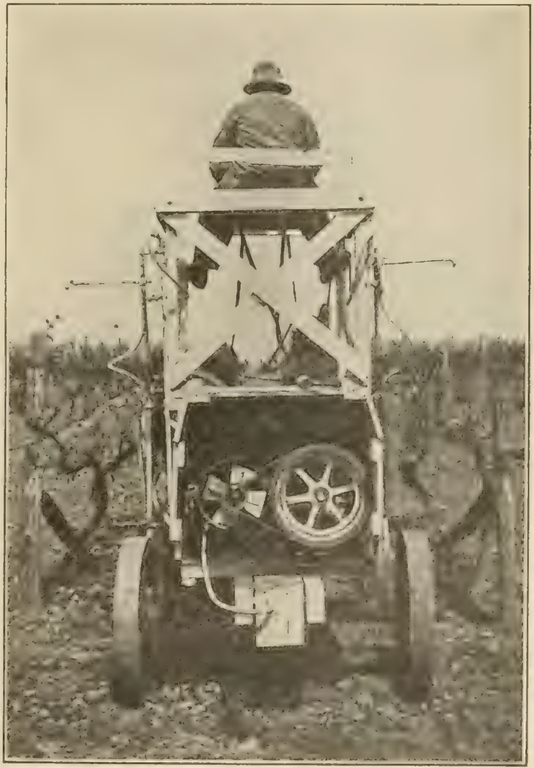

FIG. 2.—Gasoline-engine outfit used in spraying at North East, Pa., in 1907.

Plot 4 was selected for comparison with the check plot. This plot had been sprayed with 4–4–50 Bordeaux mixture, with 2 pounds of resin-fishoil soap added for the first four applications. From the check plot 1,024 8-pound baskets were picked, and 1,220 8-pound baskets from sprayed plot 4. This shows an increase of 15 per cent of fruit on the sprayed plot. The percentage of culls, according to the report of the packers, was the same from each plot, and the additional quantity of fruit on the sprayed plot could not perhaps be justly attributed entirely to the effect of spraying. The same difference of productiveness of individual vines probably enters in this case as in that already referred to in 1906.

The following table shows the treatment of plot 4:

TABLE II.—*Treatment given plot 4 at North East, Pa., in 1907.*

Date of spraying.	Fungicide used.	Stage of growth.
June 15-17	4-4-50 Bordeaux mixture plus 2 pounds of soap	Shoots 8 inches to 1 foot long.
July 9-10	do	Just before blooming.
July 20	4-4-50 Bordeaux mixture	Just after blooming.
August 9	Copper borate mixture	Berries three-fourths grown.

EXPERIMENTS IN 1908.

Work was continued in the same vineyard in 1908. The plots used covered four-fifths of an acre. Three applications each of the following mixtures were made: "A" brand concentrated lime-sulphur, 1 gallon to 50 gallons of water; Bordeaux mixture, 4-4-50, 4-3-50, and 3-2-50. The lime-sulphur burned the foliage and apparently can not be safely used in this strength on grapes. This opinion is also corroborated by the writers' experience in New York and Michigan.

This season, also, weather conditions were not favorable for the development of rot, and the benefit derived from the spraying consisted chiefly in the prevention of powdery mildew.

The yield from six of the plots was as follows:

TABLE III.—*Yield of grapes from six four-fifth-acre plots at North East, Pa., in 1908.*

No. of plot.	Fungicide used.	Yield, 8-pound baskets.
1	"A" brand lime-sulphur, 1 gallon to 50 gallons of water	432
2	4-4-50 Bordeaux mixture	554
3	4-3-50 Bordeaux mixture	479
4	4-2-50 Bordeaux mixture	479
5	3-2-50 Bordeaux mixture	430
6	Check, unsprayed	404
7	4-2-50 Bordeaux mixture	(*)
8	3-2-50 Bordeaux mixture	(*)

*No record.

It will be noted that the largest amount of fruit (554 baskets) came from plot 2. All sprayed plots produced greater amounts of fruit than the check; the increase varied from 26 to 150 baskets. Here, again, it is probable that the difference in production of individual vines has affected the result, though there was a decided benefit to the vines on all of the sprayed plots, as shown by the healthy foliage, freedom from mildew, and the general vigor and thriftiness of the plants.

The following table shows the treatment of plot 2:

TABLE IV.—*Treatment given plot 2 at North East, Pa., in 1908.*

Date of spraying.	Fungicide used.	Stage of growth.
May 25	4-4-50 Bordeaux mixture plus 6 pounds of arsenate of lead.	Shoots 8 inches long.
June 17	4-4-50 Bordeaux mixture	Through blooming.
July 21	do	Berries about three-fourths grown.

From the point of view of the prevention of black-rot alone the experiments conducted at North East gave no important results, but it is believed that they have considerable significance on account of their bearing upon the question of the desirability of annual spraying as a regular practice and as a matter of insurance.

It is the belief of some of the best grape growers, as well as of the writers, that the spraying in this vineyard has proved profitable. Though the actual amount of profit each season in dollars and cents may not have been great, the general effect upon the vineyard is very noticeable when it is compared with other vineyards of about the same age which have been treated in about the same manner with the exception of spraying. The general health, vigor, and productiveness of the sprayed vineyard is very noticeable, and this condition can probably now be preserved with perhaps only three applications each season.

The so-called "dead-arm," or necrosis as it has been named by Reddick,[a] is a more serious matter in the Pennsylvania grape belt at present than black-rot. This disease has been under investigation for several years, but the work is not yet completed. Our experiments indicate that spraying alone is not likely to prove an effective means of controlling this trouble.

WORK IN NEW YORK.

EXPERIMENTS IN 1907.

The investigation of grape diseases, with spraying experiments, was commenced in the spring of 1907 in a large vineyard of Niagara grapes in charge of Mr. C. E. Smith at Kendaia, N. Y. The plots were 1 acre each, and the vines about 20 years old. The rows ran north and south. The vineyards in this region had suffered greatly from black-rot for several years and the growers had lost faith in the efficiency of the ordinary methods of preventing the disease. This work was part of a general plan for a thorough investigation of the grape diseases of the country and their control, and especially their relations to different varieties, soils, and climatic conditions. This locality afforded exceptional opportunities for the study of certain of the grape-disease problems, especially in their relation to the Niagara grape. An urgent invitation from the growers was accepted, and through an understanding with the Cornell University Agricultural Experiment Station the work was commenced. The results of the spraying experiments for the seasons of 1907 and 1908 are here given. The technical pathological investigations are not yet ready for publication.

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[a] Reddick, Donald. Necrosis of the Grapevine. Bulletin 263, Cornell University Agricultural Experiment Station. 1909.

The fungicides used were Bordeaux mixture, 5–5–50 and 4–4–50, with and without the addition of resin soap; Burgundy mixture, No. 1 and No. 2, and 1 pound of resin soap; copper borate mixture No. 1 and 1 pound of resin soap; normal copper acetate and one-half pound of resin soap; copper chlorid with 1 pound of resin soap. Wherever soap is mentioned the resin-fishoil soap, which was used as an adhesive, is meant.

Ten plots of 1 acre each were selected for the spraying experiments. Plot 7 was a check and received no treatment. The following table shows the treatment of the different plots:

TABLE V.—*Treatment given nine plots at Kendaia, N. Y., in 1907.*

PLOT 1.

Date of spraying.	Fungicide used.	Stage of growth.
May 10	6–3–50 Bordeaux mixture	Buds swelling.
May 22	5–5–50 Bordeaux mixture	Buds ¾ to 1 inch long.
June 11	do	Shoots 8 inches to 1 foot long.
June 28	do	Beginning to bloom.
July 13	do	Berries size of small peas.
July 25	do	Berries one-half grown.
August 2	do	Berries three-fourths grown.
August 13	Burgundy mixture No. 2	Berries grown.

PLOT 2.

May 10	6–3–50 Bordeaux mixture	Buds swelling.
May 22	4–4–50 Bordeaux mixture	Buds ¾ to 1 inch long.
June 11	do	Shoots 8 inches to 1 foot long.
June 28	do	Beginning to bloom.
July 13	do	Berries size of small peas.
July 25	do	Berries one-half grown.
August 2	do	Berries three-fourths grown.
August 13	Normal copper acetate	Berries grown.

PLOT 3.

May 10	6–3–50 Bordeaux mixture	Buds swelling.
May 21	4–4–50 Bordeaux mixture, with 2 pounds of soap	Buds ¾ to 1 inch long.
June 11	4–4–50 Bordeaux mixture	Shoots 8 inches to 1 foot long.
June 28	do	Beginning to bloom.
July 13	do	Berries size of small peas.
July 25	do	Berries one-half grown.
August 2	do	Berries three-fourths grown.
August 13	Copper borate only	Berries grown.

Table V.—*Treatment given nine plots at Kendaia, N. Y., in 1907*—Continued.

PLOT 4.

Date of spraying.	Fungicide used.	Stage of growth.
May 10	6-3-50 Bordeaux mixture	Buds swelling.
May 22	Copper borate, with 2 pounds of soap	Buds ¾ to 1 inch long.
June 11	do	Shoots 8 inches to 1 foot long.
June 28	do	Beginning to bloom.
July 13	do	Berries size of small peas.
July 25	do	Berries one-half grown.
August 2	do	Berries three-fourths grown.
August 13	Copper borate only	Berries grown.

PLOT 5.

May 10	6-3-50 Bordeaux mixture	Buds swelling.
May 22	Burgundy mixture No. 2	Buds ¾ to 1 inch long.
June 11	do	Shoots 8 inches to 1 foot long.
June 28	do	Beginning to bloom.
July 13	do	Berries size of small peas.
July 25	do	Berries one-half grown.
August 2	do	Berries three-fourths grown.
August 13	Burgundy mixture only	Berries grown.

PLOT 6.

May 10	6-3-50 Bordeaux mixture	Buds swelling.
May 22	Copper chlorid mixture	Buds ¾ to 1 inch long.
June 11	do	Shoots 8 inches to 1 foot long.
June 28	do	Beginning to bloom.
July 13	do	Berries size of small peas.
July 25	do	Berries one-half grown.
August 2	do	Berries three-fourths grown.
August 13	do	Berries grown.

PLOT 8.

June 11	5-5-50 Bordeaux mixture	Shoots 8 inches to 1 foot long.
June 28	do	Beginning to bloom.
July 13	do	Berries size of small peas.
July 25	do	Berries one-half grown.
August 2	do	Berries three-fourths grown.

PLOT 9.

June 11	4-4-50 Bordeaux mixture and 2 pounds of soap	Shoots 8 inches to 1 foot long.
June 28	do	Beginning to bloom.
July 13	do	Berries size of small peas.
July 25	do	Berries one-half grown.
August 2	4-4-50 Bordeaux mixture	Berries three-fourths grown.

PLOT 10.

June 11	Copper borate mixture	Shoots 8 inches to 1 foot long.
June 28	do	Beginning to bloom.
July 13	do	Berries size of small peas.
July 25	do	Berries one-half grown.
August 2	do	Berries three-fourths grown.
August 13	Normal copper acetate	Berries grown.

The weather conditions during the season were not so favorable for the development of rot as they had been the year previous. On the unsprayed check plot the first indications of disease were found, as shown by spots on the leaves, on July 11. There was an outbreak of rot on the fruit and foliage from July 22 to July 25. The total amount of rot on the check before picking was 23.8 per cent.

The following table shows the results of the applications to the different plots:

TABLE VI.—*Results of spraying experiments on nine plots of Niagara grapes at Kendaia, N. Y., in 1907.*

No. of plot.	Number of applications given.	Fungicide used.	Rot.
			*Per cent.**
1	8	5-5-50 Bordeaux mixture, and Burgundy mixture No. 2 for last application.	8.8
2	8	4-4-50 Bordeaux mixture, and normal copper acetate and one-half pound of soap for last application	8.0
3	8	4-4-50 Bordeaux mixture plus 2 pounds of soap, and copper borate No. 1 and 1 pound of soap for last application	6.2
4	8	Copper borate mixture No. 1 and 1 pound of soap	10.1
5	8	Burgundy mixture No. 2 and 1 pound of soap	11.4
6	8	Copper chlorid mixture and 1 pound of soap	12.8
7		Check, unsprayed	23.8
8	5	5-5-50 Bordeaux mixture	6.3
9	5	4-4-50 Bordeaux mixture and soap	7.2
10	6	Copper borate and 1 pound of soap, and normal copper acetate for last application	8.3
		Ordinary spraying with Bordeaux mixture as heretofore practiced in the vineyard	12.072

* Determined by count of rotten berries.

The percentages of rot given were determined by an actual count of the diseased berries found on 2,500 clusters from vines showing the average condition of the plot and by comparing this number with the average number of berries usually produced upon the same number of clusters. (See Pl. I, figs. 1 and 2.)

It will be noted that Bordeaux mixture gave the best results and that five applications proved just about as effective as eight. There was scarcely any difference in the results from the use of the 5–5–50 and the 4–4–50 formulas. There was 2 per cent less rot on plot 3 than on plots 1 and 2, apparently attributable to the addition of the resin soap, but in other cases the benefit from this was not evident.

EXPERIMENTS IN 1908.

The work in New York was continued in the season of 1908 in the same vineyard and on the same vines used in 1907, but the plots were reduced to five-sixths of an acre each.

The following fungicides were used:

Bordeaux mixture, 4–4–50, 4–3–50, and 3–2–50 formulas.

Copper borate mixture No. 3.

Neutral copper acetate solution. This was used chiefly as a nonstaining preparation for final applications.

Self-boiled lime-sulphur, prepared with hot water.

"A" brand concentrated lime-sulphur solution, 1 gallon to 50 gallons of water; also 1 gallon to 75 gallons of water.

Resin-fishoil soap was also added in some cases, as indicated in the tables which follow.

The spraying was done, as in the preceding season, with a gasoline-engine outfit. Stationary nozzles were used for the earlier applica-

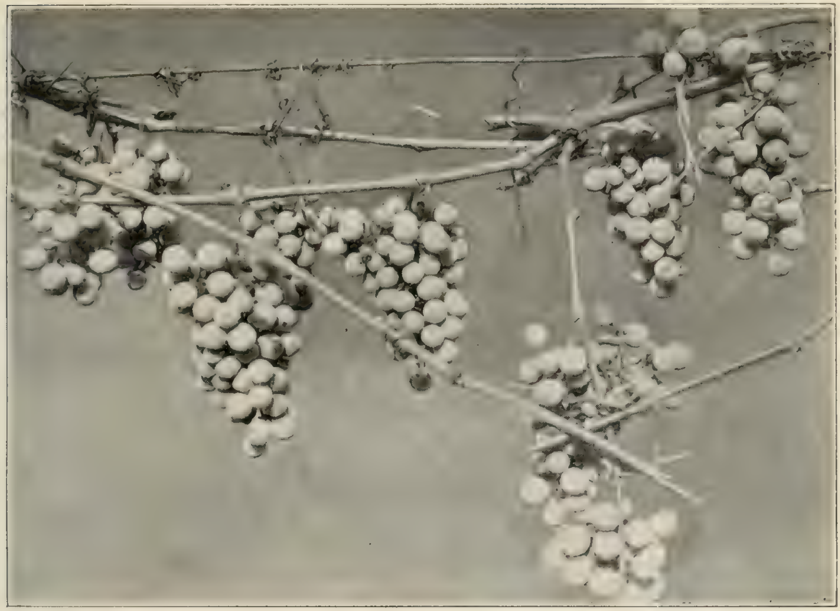

FIG. 1.—PORTION OF A NIAGARA VINE WITH THE LEAVES REMOVED, SHOWING SPRAYED FRUIT, KENDAIA, N. Y., 1907.

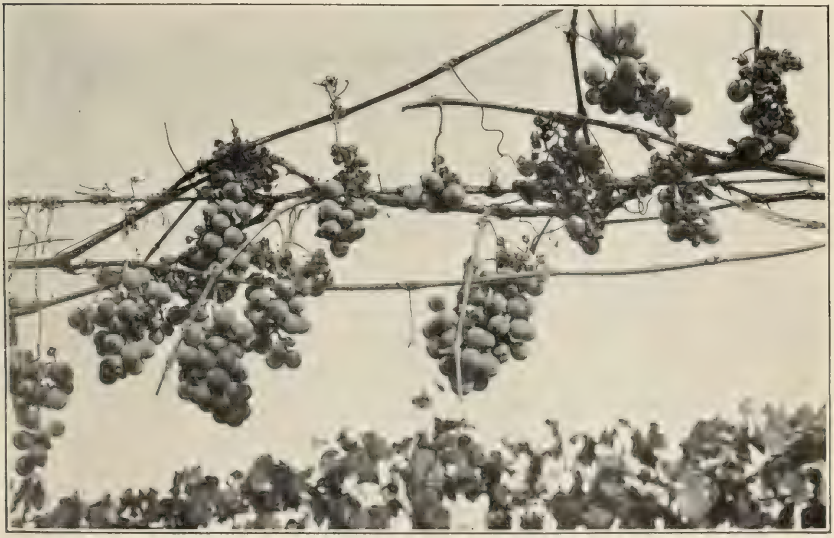

FIG. 2.—PORTION OF AN UNSPRAYED NIAGARA VINE WITH THE LEAVES REMOVED, FROM CHECK PLOT, KENDAIA, N. Y., 1907.

tions, and three fixed nozzles and trailers with two nozzles each directed by hand were used for the fifth and sixth applications. Plot 7 was a check and received no treatment.

The following table shows the treatment given each of the plots:

Table VII.—*Treatment given ten plots at Kendaia, N. Y., in 1908.*

PLOT 1.

Date of spraying.	Fungicide used.	Stage of growth.
June 1	4-4-50 Bordeaux mixture	Shoots 10 inches to 1 foot long.
June 12	do	Just beginning to bloom.
June 26	do	Through blooming.
July 8-9	do	Berries one-third grown.
July 23	do	Berries one-half grown.
August 12	Neutral copper acetate	Berries nearly grown.

PLOT 2.

June 1	4-3-50 Bordeaux mixture	Shoots 10 inches to 1 foot long.
June 12	do	Just beginning to bloom.
June 26	do	Through blooming.
July 8	do	Berries one-third grown.
July 23	do	Berries one-half grown.
August 12	Neutral copper acetate	Berries nearly grown.

PLOT 3.

June 1	4-2-50 Bordeaux mixture	Shoots 10 inches to 1 foot long.
June 12	do	Just beginning to bloom.
June 26	do	Through blooming.
July 8	do	Berries one-third grown.
July 23	do	Berries one-half grown.
August 12	Neutral copper acetate	Berries nearly grown.

PLOT 4.

June 1	3-2-50 Bordeaux mixture	Shoots 10 inches to 1 foot long.
June 12	do	Just beginning to bloom.
June 26	do	Through blooming.
July 8	do	Berries one-third grown.
July 23	do	Berries one-half grown.
August 12	Neutral copper acetate	Berries nearly grown.

PLOT 5.

June 1	4-2-50 Bordeaux mixture, with 2 pounds of soap.	Shoots 10 inches to 1 foot long.
June 12	do	Just beginning to bloom.
June 26	do	Through blooming.
July 8	do	Berries one-third grown.
July 23	4-2-50 Bordeaux mixture	Berries one-half grown.
August 12	Neutral copper acetate	Berries nearly grown.

PLOT 6.

June 1	3-2-50 Bordeaux mixture, with 2 pounds of soap.	Shoots 10 inches to 1 foot long.
June 12	do	Just beginning to bloom.
June 26	do	Through blooming.
July 8	do	Berries one-third grown.
July 23	3-2-50 Bordeaux mixture	Berries one-half grown.
August 12	Neutral copper acetate	Berries nearly grown.

PLOT 8.

June 12	4-3-50 Bordeaux mixture	Just beginning to bloom.
June 26	Copper borate No. 3, with 1 pound of soap	Through blooming.
July 9	do	Berries one-third grown.
July 23	Copper borate	Berries one-half grown.
August 12	do	Berries nearly grown.

TABLE VII.—*Treatment given ten plots at Kendaia, N. Y., in 1908*—Continued.

PLOT 9.

Date of spraying.	Fungicide used.	Stage of growth.
June 12	4-3-50 Bordeaux mixture	Just beginning to bloom.
June 26	Neutral copper acetate	Through blooming.
July 9	do	Berries one-third grown.
July 23	do	Berries one-half grown.
August 12	do	Berries nearly grown.

PLOT 10.

Date of spraying.	Fungicide used.	Stage of growth.
June 12	4-3-50 Bordeaux mixture	Just beginning to bloom.
June 26	Self-boiled lime-sulphur No. 1, 8-15-50	Through blooming.
July 9	do	Berries one-third grown.
July 23	Self-boiled lime-sulphur No. 2, 10-15-50	Berries one-half grown.
August 12	"A" brand lime-sulphur No. 2, 1 gallon to 75 gallons of water.	Berries nearly grown.

PLOT 11.

Date of spraying.	Fungicide used.	Stage of growth.
June 12	4-3-50 Bordeaux mixture	Just beginning to bloom.
June 26	"A" brand lime-sulphur No. 1, 1 gallon to 50 gallons of water.	Through blooming.
July 9	do	Berries one-third grown.
July 23	do	Berries one-half grown.
August 12	"A" brand lime-sulphur No. 2, 1 gallon to 75 gallons of water.	Berries nearly grown.

The plot which had been used as a check in 1907 was sprayed this season. The first signs of disease were noted on June 25, when spots caused by the black-rot fungus began to appear on the leaves.

The following table shows the results of the treatment of the different plots:

TABLE VIII.—*Results of spraying experiments on ten plots of Niagara grapes at Kendaia, N. Y., in 1908.*

No. of plot.	Number of applications.	Fungicide used.	Rot.	Yield of select market grapes.	Yield of wine grapes.
			*Per cent.**	*Baskets (4 lb.).*	*Baskets (20 lb.).*
1	6	4-4-50 Bordeaux mixture †	1.9	758	157
2	6	4-3-50 Bordeaux mixture	1.06	800	131
3	6	4-2-50 Bordeaux mixture	.79	610	136½
4	6	3-2-50 Bordeaux mixture	.79	608	142½
5	6	4-2-50 Bordeaux mixture and 2 pounds of resin-fishoil soap	.49	523	148
6	6	3-2-50 Bordeaux mixture and 2 pounds of resin-fishoil soap	1.6	696	160
7		Check, unsprayed	17.44	505	112
8	5	4-3-50 Bordeaux mixture, first application only. Following applications, copper borate No. 3, with 1 pound of soap	3.48	957	145
9	5	4-3-50 Bordeaux mixture, first application only. Following applications, neutral copper acetate, 1 pound to 50 gallons of water	1.01	685	105
10	5	4-3-50 Bordeaux mixture, first application only. Following applications, self-boiled lime-sulphur Nos. 1 and 2	1.1	319	150
11	5	4-3-50 Bordeaux mixture, first application only. Following applications, "A" brand lime-sulphur Nos. 1 and 2	.37	863	115

* Determined by count of rotten berries.

† Neutral copper acetate used in last spraying on plots 1 to 6, inclusive; also on plot 9.

From this table it will be noted that the smallest percentage of rot, as determined by counting the diseased berries, was upon plot 11, which was sprayed first with 4-3-50 Bordeaux mixture, followed by three applications of "A" brand concentrated lime-sulphur solution, one gallon to 50 of water, and a final application of 1 gallon of the same material to 75 of water. It was intended to treat this plot throughout the season with the concentrated lime-sulphur solution, but the material was not received in time to be used for the first application. The concentrated lime-sulphur solution, when used at the rate of 1 gallon to 50 of water, caused such severe injury to the foliage that for the final application it was reduced to 1 to 75. Hence, from the facts that this plot was not treated with the concentrated lime-sulphur solution alone, and that the injury to the foliage was so great as to preclude its future use in the same strength, the results do not justify positive conclusions in regard to either the efficiency or the practicability of using this preparation for black-rot. It remains to be determined whether this concentrated lime-sulphur can be diluted sufficiently to avoid injury to the foliage and still retain the necessary fungicidal properties. The plot treated with self-boiled lime-sulphur was also sprayed the first time with Bordeaux mixture, and as the lime-sulphur was made by the use of hot water it also caused some injury to the foliage. The fruit was also rather badly stained by the self-boiled lime-sulphur solutions.

The yield in select market grapes and wine grapes is also given. The yield from the various plots does not always bear a direct relation to the treatment and to the amount of rot present, as the number of vines in the rows varied somewhat and there was also some variation in the vigor and productiveness of the individual vines.

The following is an itemized statement of the expenses connected with the spraying and shows also the returns from the fruit and the gain per acre due to spraying:

Cost of spraying plot 2, five-sixths of an acre, at Kendaia, N. Y., in 1908, returns from plot 2, and returns from the five-sixths-acre unsprayed plot.

Plot No. 2 (sprayed):			
800 4-pound baskets, at 12 cents		$96.00	
131 20-pound baskets, at 30 cents		39.30	
Total receipts		135.30	
Man, team, and sprayer, each application	$0.35		
Bluestone, 8 pounds, at 6 cents; lime, 6 pounds, at five-ninths cent	.51⅓		
One application of Bordeaux mixture, 4–3–50	.86⅓		
Five applications of Bordeaux mixture, 4–3–50, at 86⅓ cents	4.32		
Resin-fishoil soap, 3 applications, 12 pounds, at 3½ cents	.42		
One additional application of copper acetate, 2 pounds, at 45 cents, plus 35 cents for application	1.25		
Extra help handling trailers, two applications	.60		
Packing	7.75		
Total, six applications		11.34	
Net receipts			$120.96

Net receipts, brought forward		$120.96
Plot No. 7 (unsprayed):		
505 4-pound baskets, at 12 cents	$60.60	
112 20-pound baskets, at 30 cents	33.60	
Total receipts	94.20	
Packing	16.00	
Net receipts		78.20
Gain from spraying five-sixths of an acre		42.76
Gain per acre at same rate		[a] 51.31

WORK IN MICHIGAN.

The principal grape-growing district in Michigan is located in the southwestern part of the State, Paw Paw and Lawton being the principal centers. Until a few years ago fungous diseases had not caused any very serious losses in this region. As is usually the case, it was only after grapes had been grown for a number of years and the vineyards had become quite extensive and numerous that the diseases began to be very serious. For two or three seasons previous to 1907 many of the grape growers suffered severe loss from fungous troubles, especially black-rot. This was apparently due to a combination of circumstances. The fungi causing the diseases had had sufficient time to become thoroughly established and distributed, and under the very favorable climatic conditions which prevailed—excessive heat and moisture during the growing season—proved very destructive.

Most of the growers had had no practical experience in spraying and were hoping that the troubles were of a more or less temporary character, and would perhaps soon pass away. This did not, however, prove to be the case, and during the seasons of 1906 and 1907 the losses were so general and so great that many growers were becoming disheartened. At the time the writers began work in this region few spraying outfits were in use. Some spraying had already been done there under the direction of Professor Taft, of the Michigan Agricultural Experiment Station, but few of the growers had taken up the work. The work of the Bureau of Plant Industry was undertaken in accordance with an understanding with the director of the Michigan Agricultural Experiment Station. The spraying experiments have received continuous personal direction and supervision in every detail throughout each season, and advice and assistance have been given growers whenever desired. The chief purposes of the spraying experiments were to make a comparative test of fungicides and to determine the most efficient methods of treatment under the prevailing climatic and cultural conditions, and incidentally to demon-

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[a] Six hundred gallons of Bordeaux mixture were used for the six applications on the five-sixths acre. Ordinarily this amount would be sufficient for an acre, and the gain would thus be increased to $52.62.

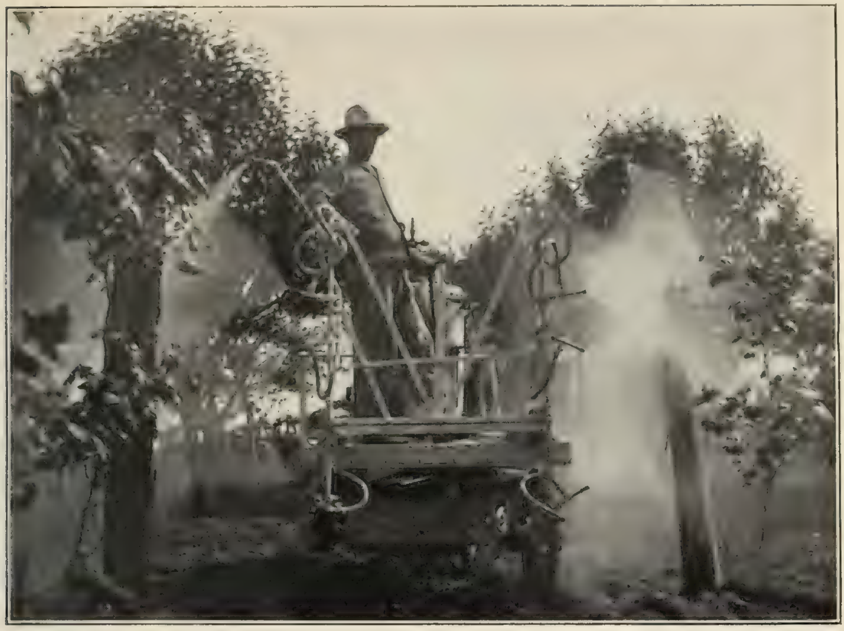

FIG. 1.—CARBONIC-ACID-GAS SPRAYER USED IN SPRAYING EXPERIMENTS IN 1907 AND 1908 IN THE VINEYARD OF MRS. EMMA R. SMITH, PAW PAW, MICH.

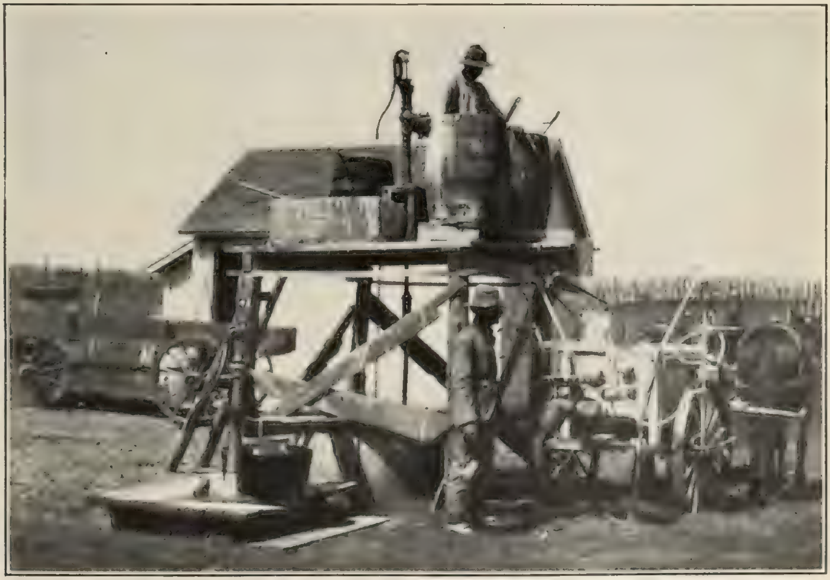

FIG. 2.—MIXING PLATFORM AND GEARED TRACTION SPRAYER USED IN SPRAYING EXPERIMENTS IN THE VINEYARD OF MR. J. M. TOWERS, PAW PAW, MICH., IN 1908.

strate the practicability of controlling black-rot even in the case of a very severe epidemic.

In 1906, so far as the writers could learn, but six sprayers were in use in the Lawton grape belt. Interest in spraying and confidence in its results have so increased that most of the growers have secured sprayers and are in nearly all cases satisfactorily controlling the black-rot. In the summer of 1908 at least two hundred spraying outfits were found in use, and perhaps there were others of which the writers did not learn. Thirteen different kinds were represented.

EXPERIMENTS IN 1907.

The work of 1907 was commenced in two vineyards in the vicinity of Paw Paw, but in one vineyard, that of Mr. J. M. Towers, it was discontinued on account of partial loss of the crop by frost and insects.

The work in the other vineyard, that of Mrs. Emma R. Smith, was continued throughout the season. This vineyard consisted of Concord vines about 25 years old, trained after the Kniffin system, with the rows running north and south. The fruit the previous season had been almost totally destroyed by rot. Four plots adjoining each other were selected. The three sprayed plots contained about 0.46 acre each, and the check 0.115 acre.

The fungicides used were as follows: 3–50 copper sulphate solution; 5–5–50 Bordeaux mixture; 4–4–50 Bordeaux mixture; 3–3–50 Bordeaux mixture. For the sixth and seventh applications, Burgundy mixture No. 2 was used in order to avoid too much staining of the fruit. The work was done with a carbonic-acid-gas sprayer. (See Pl. II, fig. 1.) The first applications were made with fixed nozzles, and the last three with trailers, the nozzles being directed by hand. In order to determine the percentage of rot present on the different plots, counts of the sound and the diseased grapes were made between September 23 and October 2, 1,000 bunches from each of the sprayed plots and 100 from the check being taken. The check, which received no treatment, was plot 3.

The following table shows the treatment of each plot:

TABLE IX.—*Treatment given three plots in Mrs. Smith's vineyard, near Paw Paw, Mich., in 1907.*

PLOT 1.

Date of spraying.	Fungicide used.	Stage of growth.
May 5	3-50 copper sulphate solution	Dormant.
June 20	3-3-50 Bordeaux mixture	Just beginning to blossom.
July 6	do	Just after blossoming.
July 16	do	Grapes about size of peas.
July 23	3-3-50 Bordeaux mixture, with 2 pounds of soap.	Grapes about one-third grown.
August 2	Burgundy mixture No. 2	Grapes about one-half grown.
August 15	do	Grapes about three-fourths grown.

TABLE IX.—*Treatment given three plots in Mrs. Smith's vineyard, near Paw Paw, Mich., in 1907*—Continued.

PLOT 2.

Date of spraying.	Fungicide used.	Stage of growth.
May 5	3-50 copper sulphate solution	Dormant.
June 20	4-4-50 Bordeaux mixture	Just beginning to blossom.
July 6	do	Just after blossoming.
July 16	do	Grapes about size of peas.
July 23	4-4-50 Bordeaux mixture, with 2 pounds of soap.	Grapes about one-third grown.
August 2	Burgundy mixture No. 2	Grapes about one-half grown.
August 15	do	Grapes about three-fourths grown.

PLOT 4.

Date of spraying.	Fungicide used.	Stage of growth.
May 5	3-50 copper sulphate solution	Dormant.
June 20	5-5-50 Bordeaux mixture	Just beginning to blossom.
July 6	do	Just after blossoming.
July 16	do	Grapes about size of peas.
July 23	do	Grapes about one-third grown.
August 2	Burgundy mixture No. 2	Grapes about one-half grown.
August 15	do	Grapes about three-fourths grown.

The amount of rot on the plots at the close of the season was determined by actual count of the number of sound and affected berries on 1,000 average bunches from each plot, as already stated.

Just across a roadway at the south end of this vineyard was another which was very severely injured by black-rot; in fact, most of the crop was destroyed before the fruit was much over half grown. In order to get some idea of the effect of this apparently serious source of infection upon the portions of the experimental plots nearest to this vineyard, counts were made of the affected grapes at both ends of the rows, those adjoining the neglected vineyard and those farthest from it.

The following table shows the percentage of rot at both ends of each plot, and also the difference between the two ends:

TABLE X.—*Comparison of the amount of rot on the ends of plots adjoining and those farthest from an unsprayed vineyard near Paw Paw, Mich., 1907.*

No. of plot.	Fungicide used.	Rot.		
		South end.*	North end.†	Difference.
		Per cent.	*Per cent.*	*Per cent.*
1	Bordeaux mixture, 3-3-50	56.4	31.2	25.2
2	Bordeaux mixture, 4-4-50	34.9	23.8	11.1
3	Check, no treatment	91.7	86.1	5.6
4	Bordeaux mixture, 5-5-50	32.7	23.1	9.6

* Adjoining unsprayed vineyard severely affected with black-rot.
† Farthest from unsprayed vineyard.

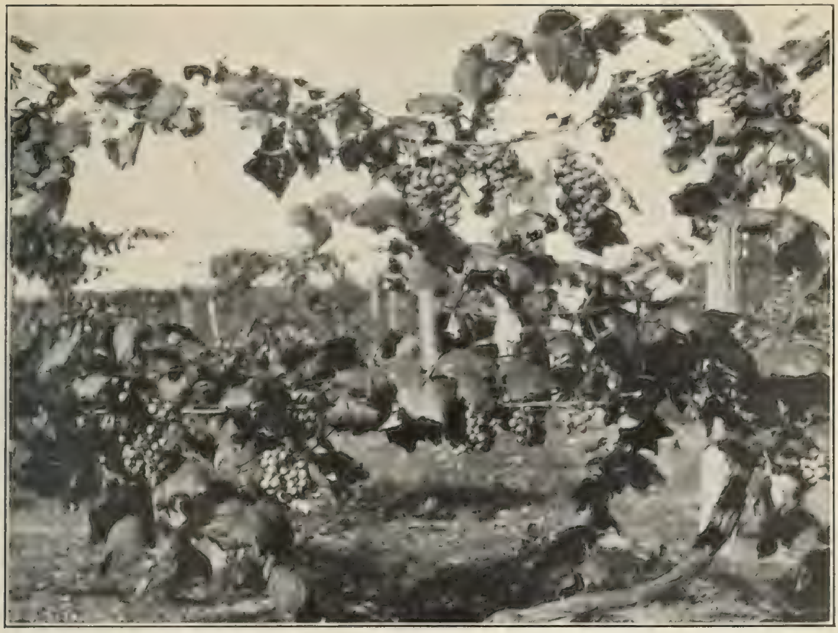

FIG. 1.—PART OF A CONCORD VINE SPRAYED WITH 5-5-50 BORDEAUX MIXTURE, MRS. SMITH'S VINEYARD, PAW PAW, MICH. PHOTOGRAPHED SEPTEMBER 8, 1907.

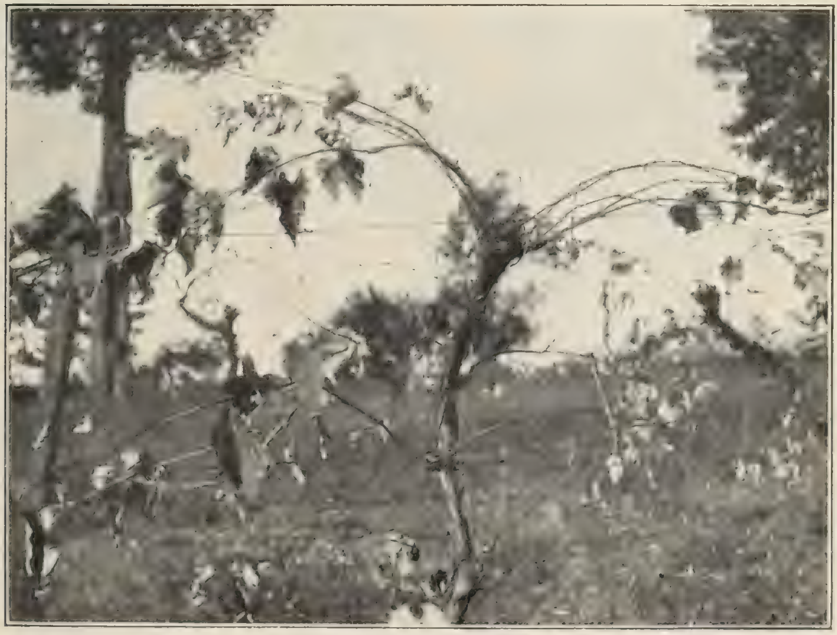

FIG. 2.—CONCORD VINE FROM UNSPRAYED AND NEGLECTED VINEYARD IN THE SAME NEIGHBORHOOD AND PHOTOGRAPHED ON THE SAME DAY AS THE VINE SHOWN IN FIGURE 1. THE CROP WAS ENTIRELY DESTROYED AND THE VINE NEARLY DEFOLIATED BY BLACK-ROT.

The average percentage of rot for the four plots is as follows:

TABLE XI.—*Results of spraying experiments on three plots of Concord grapes near Paw Paw, Mich., in 1907.*

No. of plot.	Number of applications.	Fungicide used.	Rot.
			*Per cent.**
1	7	3-3-50 Bordeaux mixture †	13.7
2	7	4-4-50 Bordeaux mixture	28.7
3	....	Check, unsprayed	89.2
4	7	5-5-50 Bordeaux mixture	28.3

* Determined by count of rotten berries.

† Soap was used in fifth spraying on plots 1 and 2 and Burgundy mixture No. 2 for the sixth and seventh sprayings on all plots.

Although only 89.2 per cent of the fruit on the unsprayed plot was found by actual count to be destroyed, it was not considered practicable to try to harvest any of it because the expense of separating the small quantity of sound fruit would have been much more than its value. The crop on the unsprayed plot was therefore practically a total loss. It will be noted that there was scarcely any difference in the amount of rot on the plot sprayed with 4-4-50 and on that sprayed with 5-5-50 Bordeaux mixture. Part of a vine from the latter plot and a typical vine from a neighboring neglected vineyard are shown in Plate III. On the neglected vine the fruit was not only completely destroyed, but the plant was defoliated and thus prevented from properly maturing the season's growth of wood.

The following itemized account shows the gain due to spraying on plot 2 (five applications with 4-4-50 Bordeaux mixture and two with Burgundy mixture, or 475 gallons in all, on 0.46 acre) and the corresponding gain per acre estimated upon the same basis:

Receipts and expenditures, plot 2, Paw Paw, Mich., 1907.

2,010 pounds grapes, at $40 a ton		[a] $40.20
Man and team to spray, 8¾ hours, at 35 cents	$3.06	
Man and horse to haul mixture, 8¾ hours, at 25 cents	2.19	
Two men to carry trailers for last three sprayings, 5¼ hours, at 15 cents an hour each	1.58	
Two-thirds tube of gas, at $2.35	1.57	
Copper sulphate, 26 pounds, at 8¾ cents	2.28	
Resin-fishoil soap, 11 pounds, at 3½ cents	.39	
Sal soda, 6 pounds, at 3 cents	.18	
Total cost of spraying plot, 0.46 acre		11.25
Gain from spraying on 0.46 acre		28.95
Gain per acre at same rate		62.93

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[a] As no fruit was harvested on the unsprayed plot at Paw Paw, Mich., in 1907, this amount is all attributed to spraying.

EXPERIMENTS IN 1908.

The work in 1908 was carried on in three different vineyards: Mrs. Emma Smith's, as already described; Mr. J. M. Towers's, near Paw Paw; and Mr. C. C. Giddings's vineyard, near Lawton. The work in Mrs. Smith's vineyard was conducted on the same plots used in 1907 and with the same spraying outfit and, as before, trailers with nozzles directed by hand instead of fixed nozzles were used for the last three sprayings. It was found that in order to satisfactorily cover the foliage and fruit at the time of the later applications the nozzles, or part of them at least, must be thus manipulated.

EXPERIMENTS IN MRS. SMITH'S VINEYARD, NEAR PAW PAW, MICH.

The treatment given the different plots in Mrs. Smith's vineyard is shown in the following table. Plot 2 was a check and received no treatment.

TABLE XII.—*Treatment given three plots in Mrs. Smith's vineyard, near Paw Paw, Mich., in 1908.*

PLOT 1.

Date of spraying.	Fungicide used.	Stage of growth.
May 19	4-4-50 Bordeaux mixture	Shoots about 6 inches long.
May 29	do	Shoots 18 to 24 inches long.
June 2	do	Shoots 20 to 28 inches long.
June 15	do	Just after blooming.
June 24	do	Grapes about the size of peas.
July 3	do	Grapes about one-half grown.
July 22	4-2-50 Bordeaux mixture	Grapes about four-fifths grown.

PLOT 3.

Date of spraying.	Fungicide used.	Stage of growth.
May 19	4-3-50 Bordeaux mixture	Shoots about 6 inches long.
May 29	do	Shoots 18 to 24 inches long.
June 2	do	Shoots 20 to 28 inches long.
June 15	do	Just after blooming.
June 24	do	Grapes about the size of peas.
July 3	do	Grapes about one-half grown.
July 6	do	Grapes about one-half grown.
July 22	4-2-50 Bordeaux mixture	Grapes about four-fifths grown.

PLOT 4.

Date of spraying.	Fungicide used.	Stage of growth.
May 19	4-2-50 Bordeaux mixture	Shoots about 6 inches long.
May 29	do	Shoots 18 to 24 inches long.
June 2	do	Shoots 20 to 28 inches long.
June 15	do	Just after blooming.
June 24	do	Grapes about the size of peas.
July 6	do	Grapes about one-half grown.
July 22	do	Grapes about four-fifths grown.

The following table shows the percentage of rot as determined by actual count, as in the preceding season's work:

TABLE XIII.—*Results of spraying experiments on three plots of Concord grapes in Mrs. Smith's vineyard, near Paw Paw, Mich., in 1908.*

No. of plot.	Number of applications.	Fungicide used.	Rot.
			Per cent.
1	7	4-4-50 Bordeaux mixture	0.197
2		Check, unsprayed (but sprayed in 1907)	17.257
3	8	4-3-50 Bordeaux mixture	.034
4	7	4-2-50 Bordeaux mixture	.178

The small amount of rot on the check plot was believed to be largely due to the fact that this plot was sprayed in the season of 1907. It would have been better, perhaps, for purposes of comparison, to have used the same check as in 1907. As the amount of rot in a neglected vineyard near by was as great in 1908 as in the previous year, there seems to be no reason to suppose that the rot on this unsprayed plot would not have been about as great also, except for the treatment given it in 1907.

It will be noted that in this experiment the plots sprayed with 4-3-50 Bordeaux mixture showed the least amount of rot. The very small percentage of rot on all the plots illustrates very clearly what may perhaps be called the cumulative effect of spraying. The disease having been largely brought under control the first season can generally be much more easily handled during succeeding seasons.

The following is an itemized account of the work, showing the gain on plot 3, 0.46 acre, which received seven sprayings with 4-3-50 Bordeaux mixture and one with 4-2-50, 500 gallons in all:

Receipts and expenditures, plot 3, Mrs. Smith's vineyard, near Paw Paw, Mich., 1908.

Yield from plot 3, sprayed, 660 8-pound baskets, at 11.66 cents		$76.96	
Receipts per acre at same rate			$167.30
Yield from check plot, 1,134.75 pounds, at $20.64 a ton		11.71	
Receipts per acre at same rate			101.83
Gain per acre due to spraying			65.47
Man and team to spray, 10 hours, at 35 cents	$3.50		
Man and horse to haul mixture, 10 hours, at 25 cents	2.50		
Two men to carry trailers for last four sprayings, 6 hours, at 15 cents an hour each	1.80		
Copper sulphate, 40 pounds, at 6¾ cents	2.70		
Stone lime, 30 pounds, at two-thirds of a cent	.20		
Five-sevenths tube of gas, at $2.35	1.68		
Total cost of spraying plot, 0.46 acre	12.38		
Cost of spraying 1 acre at same rate			26.91
Net gain per acre due to spraying			[a] 38.56

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[a] Grapes in same vineyard sprayed five times showed no appreciable difference in amount of rot. Difference in net gain this year was due to extra sprayings and to less loss on check as result of previous treatment (1907).

EXPERIMENTS IN MR. TOWERS'S VINEYARD, NEAR PAW PAW, MICH.

In 1908 spraying experiments were again started in Mr. J. M. Towers's vineyard, near Paw Paw. This vineyard consisted of Concord vines about 8 years old, with the rows running north and south. Nine plots, 0.488 acre each, as nearly uniform in character and condition as possible, were selected. The work was done with the geared traction sprayer shown in Plate II, figure 2. The mixing platform used is also shown in the same figure.

The following fungicides were used: Bordeaux mixture, 4–4–50, 4–3–50, 4–2–50, 5–5–50, 5–4–50, and 5–3–50; also sodium benzoate Bordeaux mixtures Nos. 1 and 2. Six applications were made, as shown in the accompanying tables, the last one consisting of 4–2–50 Bordeaux mixture. Plot 4 was a check and received no treatment.

TABLE XIV.—*Treatment given eight plots in Mr. Towers's vineyard, near Paw Paw, Mich., in 1908.*

PLOT 1.

Date of spraying.	Fungicide used.	Stage of growth.
May 20	4-4-50 Bordeaux mixture	Shoots about 8 inches long.
May 30	do	Shoots 16 to 20 inches long.
June 17	do	Just after blossoming.
June 29	do	Grapes the size of peas.
July 13	do	Grapes about three-fourths grown.
July 25	4-2-50 Bordeaux mixture	Grapes nearly full grown.

PLOT 2.

Date of spraying.	Fungicide used.	Stage of growth.
May 20	4-3-50 Bordeaux mixture	Shoots about 8 inches long.
May 30	do	Shoots 16 to 20 inches long.
June 17	do	Just after blossoming.
June 29	do	Grapes the size of peas.
July 13	do	Grapes about three-fourths grown.
July 25	4-2-50 Bordeaux mixture	Grapes nearly full grown.

PLOT 3.

Date of spraying.	Fungicide used.	Stage of growth.
May 20	4-2-50 Bordeaux mixture	Shoots about 8 inches long.
May 30	do	Shoots 16 to 20 inches long.
June 17	do	Just after blossoming.
June 30	do	Grapes the size of peas.
July 13	do	Grapes about three-fourths grown.
July 25	do	Grapes nearly full grown.

PLOT 5.

Date of spraying.	Fungicide used.	Stage of growth.
May 20	5-5-50 Bordeaux mixture	Shoots about 8 inches long.
May 30	do	Shoots 16 to 20 inches long.
June 17	do	Just after blossoming.
June 30	do	Grapes the size of peas.
July 13	do	Grapes about three-fourths grown.
July 25	4-2-50 Bordeaux mixture	Grapes nearly full grown.

PLOT 6.

Date of spraying.	Fungicide used.	Stage of growth.
May 20	5-4-50 Bordeaux mixture	Shoots about 8 inches long.
May 30	do	Shoots 16 to 20 inches long.
June 17	do	Just after blossoming.
June 30	do	Grapes the size of peas.
July 13	do	Grapes about three-fourths grown.
July 25	4-2-50 Bordeaux mixture	Grapes nearly full grown.

TABLE XIV.—*Treatment given eight plots in Mr. Towers's vineyard, near Paw Paw, Mich., in 1908*—Continued.

PLOT 7.

Date of spraying.	Fungicide used.	Stage of growth.
May 20	5-3-50 Bordeaux mixture	Shoots about 8 inches long.
June 1	do	Shoots 16 to 20 inches long.
June 17	do	Just after blossoming.
June 30	do	Grapes the size of peas.
July 13	do	Grapes about three-fourths grown.
July 25	4-2-50 Bordeaux mixture	Grapes nearly full grown.
PLOT 8.		
May 20	Sodium benzoate Bordeaux mixture No. 2, 1-1-½-50.	Shoots about 8 inches long.
June 1	do	Shoots 16 to 20 inches long.
June 18	do	Just after blossoming.
June 30	do	Grapes the size of peas.
July 14	do	Grapes about three-fourths grown.
July 25	4-2-50 Bordeaux mixture	Grapes nearly full grown.
PLOT 9.		
May 20	Sodium benzoate Bordeaux mixture No. 1, 2-1-1-50.	Shoots about 8 inches long.
June 1	do	Shoots 16 to 20 inches long.
June 18	do	Just after blossoming.
June 30	do	Grapes the size of peas.
July 14	do	Grapes about three-fourths grown.
July 25	4-2-50 Bordeaux mixture	Grapes nearly full grown.

The results of these experiments are shown in the following table:

TABLE XV.—*Results of spraying experiments on eight plots of Concord grapes in Mr. Towers's vineyard, near Paw Paw, Mich., in 1908.*

No. of plot.	Number of applications.	Fungicide used.	Rot.
			*Per cent.**
1	6	4-4-50 Bordeaux mixture, first five applications†	0.03
2	6	4-3-50 Bordeaux mixture, first five applications	0.097
3	6	4-2-50 Bordeaux mixture	0.042
4		Check, unsprayed	7.36
5	6	5-5-50 Bordeaux mixture, first five applications	0.051
6	6	5-4-50 Bordeaux mixture, first five applications	0.07
7	6	5-3-50 Bordeaux mixture, first five applications	0.064
8	6	Sodium benzoate Bordeaux mixture No. 2	0.083
9	6	Sodium benzoate Bordeaux mixture No. 1	0.127

* Determined by count of rotten grapes.

† Bordeaux mixture 4-2-50 was used in sixth spraying on all plots.

The percentages of rot given were obtained by actual count of the rotten grapes on clusters showing the average condition of each plot, as in the other cases. It will be noted that the smallest percentage of rot was found on plot 1, treated with 4–4–50 Bordeaux mixture. The difference in amount of rot, however, on the various plots was so slight in most cases as to give no very decided indication of the comparative value of the different mixtures. The amount of rot on the check plot was also small.

EXPERIMENTS IN MR. GIDDINGS'S VINEYARD, NEAR LAWTON, MICH.

Mr. Giddings's vineyard consisted of Concord vines about 14 years old. Eleven plots of one-third acre each were used in the experiments.

The work was done with a geared traction sprayer, fixed nozzles being used for the first three applications, and trailers, with the nozzles directed by hand, for the last three applications. Plot 5 was a check and was not sprayed.

The following table shows the treatment given each plot:

TABLE XVI.—*Treatment given ten plots in Mr. Giddings's vineyard, near Lawton, Mich., in 1908.*

PLOT 1.

Date of spraying.	Fungicide used.	Stage of growth.
May 21	4-4-50 Bordeaux mixture	Shoots about 8 inches long.
June 2	do	Shoots about 18 to 24 inches long.
June 15	do	Just after blossoming.
June 25	do	Grapes the size of peas.
July 8	do	Grapes about one-half grown.
July 23	4-2-50 Bordeaux mixture	Grapes nearly full grown.

PLOT 2.

May 21	4-3-50 Bordeaux mixture	Shoots about 8 inches long.
June 2	do	Shoots 18 to 24 inches lnog.
June 15	do	Just after blossoming.
June 25	do	Grapes the size of peas.
July 8	do	Grapes about one-half grown.
July 23	4-2-50 Bordeaux mixture	Grapes nearly full grown.

PLOT 3.

May 21	4-2-50 Bordeaux mixture	Shoots about 8 inches long.
June 2	do	Shoots 18 to 24 inches long.
June 15	do	Just after blossoming.
June 25	do	Grapes the size of peas.
July 8	do	Grapes about one-half grown.
July 23	do	Grapes nearly full grown.

PLOT 4.

May 21	3-2-50 Bordeaux mixture	Shoots about 8 inches long.
June 2	do	Shoots 18 to 24 inches long.
June 15	do	Just after blossoming.
June 25	do	Grapes the size of peas.
July 8	do	Grapes about one-half grown.
July 23	4-2-50 Bordeaux mixture	Grapes nearly full grown.

PLOT 6.

May 21	4-2-50 Bordeaux mixture, with 2 pounds of soap.	Shoots about 8 inches long.
June 2	do	Shoots 18 to 24 inches long.
June 15	do	Just after blossoming.
June 25	do	Grapes the size of peas.
July 8	do	Grapes about one-half grown.
July 23	4-2-50 Bordeaux mixture	Grapes nearly full grown.

PLOT 7.

May 21	3-2-50 Bordeaux mixture, with 2 pounds of soap.	Shoots about 8 inches long.
June 2	do	Shoots 18 to 24 inches long.
June 15	do	Just after blossoming.
June 25	do	Grapes the size of peas.
July 8	do	Grapes about one-half grown.
July 23	4-2-50 Bordeaux mixture	Grapes nearly full grown.

TABLE XVI.—*Treatment given ten plots in Mr. Giddings's vineyard, near Lawton, Mich., in 1908*—Continued.

PLOT 8.

Date of spraying.	Fungicide used.	Stage of growth.
May 21	Copper borate mixture No. 2	Shoots about 8 inches long.
June 2	do	Shoots 18 to 24 inches long.
June 15	do	Just after blossoming.
June 25	do	Grapes the size of peas.
July 8	do	Grapes about one-half grown.
July 23	4-2-50 Bordeaux mixture	Grapes nearly full grown.

PLOT 9.

Date of spraying.	Fungicide used.	Stage of growth.
May 21	Neutral copper acetate	Shoots about 8 inches long.
June 2	do	Shoots 18 to 24 inches long.
June 15	do	Just after blossoming.
June 25	do	Grapes the size of peas.
July 8	do	Grapes about one-half grown.
July 23	4-2-50 Bordeaux mixture	Grapes nearly full grown.

PLOT 10.

Date of spraying.	Fungicide used.	Stage of growth.
May 21	Self-boiled lime-sulphur No. 2	Shoots about 8 inches long.
June 2	do	Shoots 18 to 24 inches long.
June 16	do	Just after blossoming.
June 26	do	Grapes the size of peas.
July 8	do	Grapes about one-half grown.
July 23	4-2-50 Bordeaux mixture	Grapes nearly full grown.

PLOT 11.

Date of spraying.	Fungicide used.	Stage of growth.
May 21	"B" brand lime-sulphur, 1 to 50	Shoots about 8 inches long.
June 2	do	Shoots 18 to 24 inches long.
June 16	do	Just after blossoming.
June 26	do	Grapes the size of peas.
July 9	do	Grapes about one-half grown.
July 23	4-2-50 Bordeaux mixture	Grapes nearly full grown.

As the grape berry-moth was causing considerable loss in Mr. Giddings's vineyard, an arsenical preparation made in accordance with the directions of Prof. A. L. Quaintance, of the Bureau of Entomology, was added to the Bordeaux mixture for the second, third, and fourth applications on all the plots.

The following table shows the results of the treatment of each plot:

TABLE XVII.—*Results of spraying experiments on ten plots of Concord grapes in Mr. Giddings's vineyard, near Lawton, Mich., in 1908.*

No. of plot.	Number of applications.	Fungicide used.	Rot.	Yield.
			*Per cent.**	*Baskets (8 lb.).*
1	6	4-4-50 Bordeaux mixture †	0.051	187
2	6	4-3-50 Bordeaux mixture	0.043	166
3	6	4-2-50 Bordeaux mixture	0.15	148
4	6	3-2-50 Bordeaux mixture	0.17	120
5		Check, unsprayed	28.317	78
6	6	4-2-50 Bordeaux mixture, with 2 pounds of soap	0.411	137
7	6	3-2-50 Bordeaux mixture, with 2 pounds of soap	0.531	140
8	6	Copper borate mixture No. 2, with 1 pound of soap	2.464	125
9	6	Neutral copper acetate, 1 to 50	1.088	134
10	6	Self-boiled lime-sulphur No. 2	2.413	102
11	6	"B" brand lime-sulphur, 1 to 50	3.383	(‡)

* Determined by count of rotten berries.
† Bordeaux mixture 4-2-50 was used for the sixth application on all the plots.
‡ Record wanting.

The percentages of rot were determined by actual count of the diseased berries on 1,000 average bunches, as in the previous cases. The yield in 8-pound baskets is also given for each plot except the last, the record of which is missing. The smallest percentage of rot, as indicated in Table XVII, was found on plot 2, treated with 4–3–50 Bordeaux mixture. The difference between this plot and plot 1, treated with 4–4–50 Bordeaux mixture, is, however, very slight. A portion of a vine from plot 2, showing the condition of the fruit, is illustrated in Plate IV, figure 1, and a portion of a vine from the unsprayed check, showing the general appearance of the fruit, is illustrated in Plate IV, figure 2. The lime-sulphur mixtures produced decidedly less satisfactory results than the Bordeaux mixtures. The self-boiled lime-sulphur, which was prepared with hot water, injured the foliage somewhat, and the "B" brand concentrated solution at the rate of 1 gallon to 50 gallons of water burned the foliage still more seriously, and therefore is unsafe to use in this strength. The results of the treatment with lime-sulphur were so much less satisfactory in this case than in the New York experiments in 1908, in which the first application was made with Bordeaux mixture, that considerable doubt is thrown upon the part played by lime-sulphur in controlling the rot in that case. Further experiments are needed to determine whether lime-sulphur solutions in any form or strength in which they can be used will prove a desirable substitute for Bordeaux mixture. The neutral copper acetate solution, 1 pound to 50 gallons of water, gave better results than any of the other applications except Bordeaux mixture.

The following account shows the expense of spraying and the gain from plot 2, one-third of an acre, sprayed six times with 4–3–50 Bordeaux mixture, 258 gallons being applied, and the estimated gain per acre at the same rate:

Receipts and expenditures, plot 2, Mr. Giddings's vineyard, near Lawton, Mich., 1908.

Yield from plot 2, sprayed, 166 8-pound baskets, at 12½ cents		$20.75
Yield from check plot, 119 8-pound baskets, at 12½ cents		14.87½
Gain due to spraying		5.87½
Man and team, 2 hours, at 35 cents	$0.70	
Two men to carry trailers for last three sprayings, 1 hour, at 15 cents each	.30	
Copper sulphate, 20⅔ pounds, at 6 cents	1.24	
Stone lime, 15⅓ pounds, at two-thirds of a cent	.10	
Total cost of spraying plot, one-third of an acre		2.34
Net gain due to spraying on one-third of an acre		3.53½
Net gain per acre at same rate		10.60½

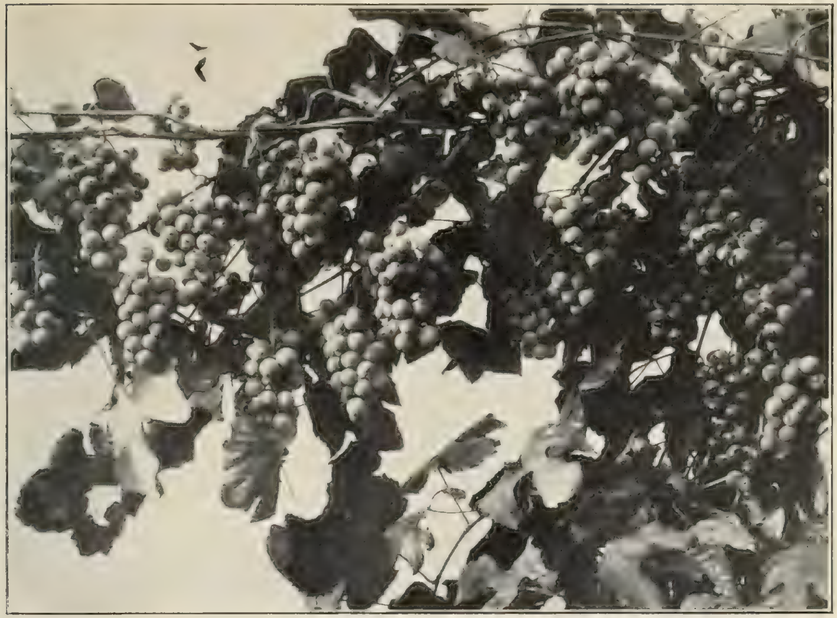

FIG. 1.—GRAPES ON PLOT SPRAYED WITH 4-3-50 BORDEAUX MIXTURE IN THE VINEYARD OF MR. C. C. GIDDINGS, NEAR LAWTON, MICH. PHOTOGRAPHED SEPTEMBER 12, 1908. THE LOSS FROM BLACK-ROT WAS LESS THAN FIVE ONE-HUNDREDTHS OF ONE PER CENT.

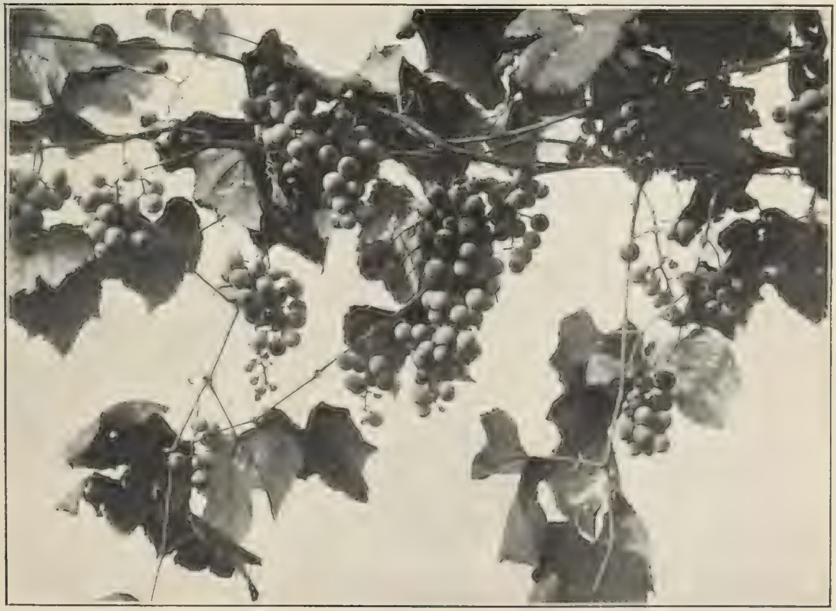

FIG. 2.—GRAPES ON UNSPRAYED CHECK PLOT IN THE SAME VINEYARD AND PHOTOGRAPHED ON THE SAME DAY AS THE VINE SHOWN IN FIGURE 1. MORE THAN TWENTY-EIGHT PER CENT OF THE FRUIT WAS DESTROYED BY BLACK-ROT.

There was an additional loss on the check plot of 15.6 per cent, due to the berry-moth, making a total loss of 43.9 per cent. As this loss was almost entirely prevented on the sprayed plots without additional cost except for the poison used, the above statement does not show all the profit due to spraying.

WORK IN NEW JERSEY.

EXPERIMENTS IN 1908.

In former years the Concord grape was rather extensively grown in New Jersey, especially for the manufacture of grape juice. The black-rot soon became troublesome, owing to some extent, no doubt, to the climatic conditions which favor its development. Some of the earliest experiments in spraying to control the disease in this country were undertaken at Vineland, N. J., by the Department of Agriculture, in 1887. The results obtained were very satisfactory, considering the fact that spraying had only recently been introduced and that mixtures and machines were in a very crude and unsatisfactory state.

In recent years the Concord grape has been largely abandoned in New Jersey and other more disease-resistant varieties introduced. Many of these varieties, however, are not so productive or as well adapted to the manufacture of juice.

At the request of those interested in the industry and in cooperation with the New Jersey Agricultural Experiment Station the Department of Agriculture has undertaken to demonstrate that by proper methods of spraying practiced in connection with better methods of pruning, training, and cultivation, the Concord grape can still be successfully and profitably grown in that region. The part of the work pertaining to pruning, training, and cultivation was undertaken by the Office of Field Investigations in Pomology of the Bureau of Plant Industry and carried out under the immediate direction of Mr. George C. Husmann, Pomologist in Charge of Viticultural Investigations.

A small Concord vineyard, one of the very few still remaining in this region, located on the grounds of the New Jersey Training School for the Feeble Minded, at Vineland, was very kindly placed at the disposal of the writers by Professor Johnstone, superintendent of the school. The total area was about 0.75 acre. Three rows, which were pruned according to different methods, were sprayed for comparison with a single unsprayed check row, which was pruned according to the ordinary system that had been followed in the vineyard. This was a modified Kniffin system. The spraying was done with a hand pump attached to a barrel which was drawn in a cart.

The following table shows the treatment of the vineyard. As rose-bugs are usually very troublesome here, 3 pounds of arsenate of lead were added to the Bordeaux mixture for the second and third applications.

TABLE XVIII.—*Treatment given a vineyard of Concord grapes at Vineland, N. J., in 1908.*

Date of spraying.	Fungicide used.	Stage of growth.
May 4	4-3-50 Bordeaux mixture	Shoots 6 to 8 inches long.
May 20	4-3-50 Bordeaux mixture, with 3 pounds of arsenate of lead.	Flowers almost ready to open.
June 8	do	Just passed blooming.
June 26	4-3-50 Bordeaux mixture	Fruit about one-third grown.
July 27	3-1-50 Bordeaux mixture	Fruit nearly grown.

The last application, of 3-1-50 Bordeaux mixture, left very little stain on the fruit and showed no signs of injury to the foliage. It gives some promise, therefore, of success as a final application when too much staining of the fruit is objectionable.

The results of the spraying were as follows: Row 1, pruned and trained according to a modified Munson system, produced 347 pounds of sound fruit; row 2, treated the same as row 1, produced 267 pounds of sound fruit. Half of row 2, pruned and trained according to a modified Munson system, produced 157 pounds of sound fruit; the other half, pruned and trained according to the Kniffin system, produced 110 pounds. This appears to show a difference of 47 pounds of fruit apparently attributable to the method of pruning and training. Row 3, which was the check row, received no spraying and was pruned according to the ordinary practice of the neighborhood. This produced only 114 pounds of fruit. It was estimated, however, that half of the loss on this row was due to rose-bugs which destroyed the young fruit immediately after the blossoms fell. The rose-bugs, however, were picked by hand from both the sprayed and the unsprayed rows.

There was practically no loss from black-rot on the sprayed rows, as only occasionally could a diseased berry be found. Comparing each of the sprayed rows with the check row, the following results are obtained:

TABLE XIX.—*Results of spraying and pruning experiments on a vineyard of Concord grapes at Vineland, N. J., in 1908.*

No. of row.	Production.	Total loss.	Loss by rose-bugs.	Loss by black-rot.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*
1 (sprayed)	347	(No loss.)	(No loss.)	(No loss.)	00.0
3 (check)	114	233	116½	116½	31.3
2 (sprayed)	267	(No loss.)	(No loss.)	(No loss.)	00.0
3 (check)	114	153	76½	76½	31.9

The average of the crops from the two sprayed rows is 307 pounds. The crop on the check row being only 114 pounds shows a loss of 193 pounds; allowing one-half of this for loss by rose-bugs, the loss of

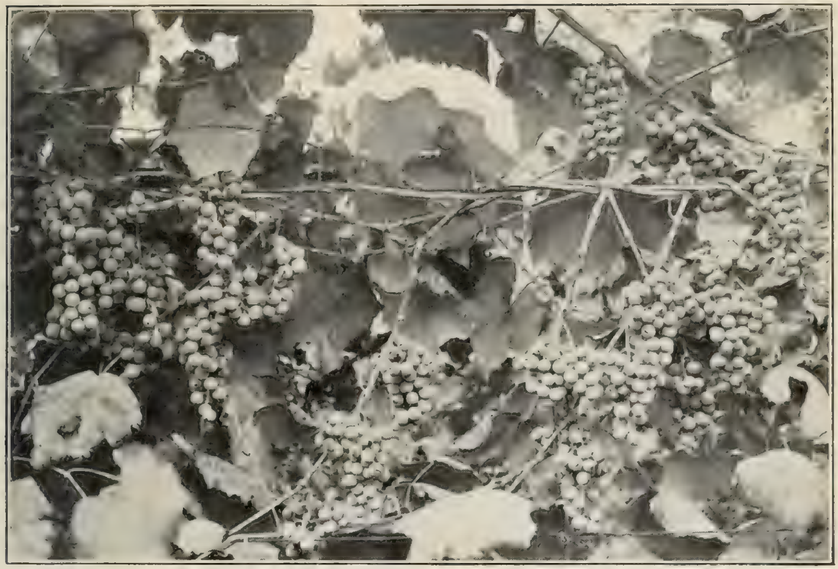

FIG. 1.—PORTION OF A VINE SPRAYED WITH BORDEAUX MIXTURE, VINELAND, N. J., 1908, SHOWING PRACTICALLY NO LOSS FROM BLACK-ROT.

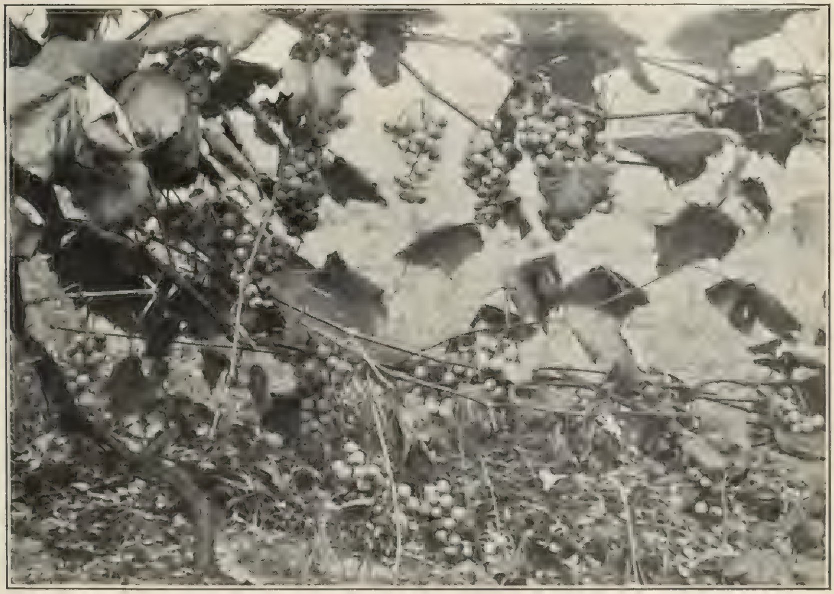

FIG. 2.—PORTION OF AN UNSPRAYED CHECK ROW IN THE SAME VINEYARD AS THE VINE SHOWN IN FIGURE 1, 1908, SHOWING 31 PER CENT OF LOSS FROM BLACK-ROT AND ABOUT THE SAME AMOUNT OF LOSS FROM ROSE-BUGS.

96.5 pounds, or 31.4 per cent, was caused by black-rot. In other words, the sprayed rows show practically no loss from rot and the unsprayed check row shows over 31 per cent, or a total loss of over 62 per cent, when the injury from rose-bugs, which was also largely prevented by the spraying, is added.

A portion of a sprayed vine showing the condition of the fruit is illustrated in Plate V, figure 1, and a part of an unsprayed vine from the check row is shown in figure 2 of the same plate.

COMPARISON OF RESULTS OBTAINED WITH DIFFERENT FORMULAS OF BORDEAUX MIXTURE.

The following table gives in condensed form the results of the tests of different formulas of Bordeaux mixture:

Table XX.—*Comparison of results secured from use of different formulas of Bordeaux mixture.*

Formula used.	Year.	Number of applications.	Results.
PENNSYLVANIA.			
			Yield, baskets.
4-4-50 Bordeaux mixture	1908	3	554
4-3-50 Bordeaux mixture	1908	3	479
NEW YORK.			
			Rot, per cent.
4-4-50 Bordeaux mixture, with soap	1907	7	6.6
5-5-50 Bordeaux mixture	1907	5	6.3
4-4-50 Bordeaux mixture, with soap	1907	5	7.2
4-2-50 Bordeaux mixture, with soap	1908	6	0.49
4-2-50 Bordeaux mixture	1908	6	0.79
3-2-50 Bordeaux mixture	1908	6	0.79
4-3-50 Bordeaux mixture	1908	6	1.06
4-4-50 Bordeaux mixture	1908	6	1.9
MICHIGAN (MRS. SMITH'S).			
5-5-50 Bordeaux mixture	1907	7	28.3
4-4-50 Bordeaux mixture, with soap	1907	7	28.7
4-3-50 Bordeaux mixture	1908	7	0.034
4-2-50 Bordeaux mixture	1908	7	0.178
4-4-50 Bordeaux mixture	1908	7	0.197
MICHIGAN (MR. TOWERS'S).			
4-4-50 Bordeaux mixture	1908	6	0.03
4-2-50 Bordeaux mixture	1908	6	0.042
5-5-50 Bordeaux mixture	1908	6	0.051
5-3-50 Bordeaux mixture	1908	6	0.064
Do	1908	6	0.097
MICHIGAN (MR. GIDDINGS'S).			
4-3-50 Bordeaux mixture	1908	6	0.043
4-4-50 Bordeaux mixture	1908	6	0.051
4-2-50 Bordeaux mixture	1908	6	0.15
3-2-50 Bordeaux mixture	1908	6	0.17
4-2-50 Bordeaux mixture, with soap	1908	6	0.41

From a comparison of these tables it may perhaps be justifiable to draw some tentative conclusions in regard to the best formula for Bordeaux mixture as a preventive of black-rot.

In the cases in which the 4–4–50 formula was used in comparison with the 5–5–50 formula, the former proved best in New York in 1907 and in Michigan in 1908, and gave almost equally satisfactory results in Michigan in 1907, there being only four-tenths of 1 per cent difference shown.

In the cases in which the 4–3–50 formula was compared with the 4–4–50 formula, the former gave slightly better results in New York in 1908 and decidedly better results in Michigan in Mrs. Smith's vineyard in 1908, and slightly better results in Michigan in Mr. Giddings's vineyard in 1908. There was very little difference in the results in the other cases in which these formulas were used—Pennsylvania in 1908 and Michigan, Mr. Towers's vineyard, in 1908. The 4–3–50 mixture gave entirely satisfactory results in the New Jersey experiment also.

The 4–2–50 formula gave better results than either the 4–4–50 or the 4–3–50 formula in one case, New York, 1908, and was second best in two other experiments, Michigan, Mrs. Smith's vineyard, 1908, and Mr. Towers's vineyard, 1908.

The 3–2–50 formula did not stand above third place in any of the cases in which it was used.

The 4–4–50 formula is found at the head of the table in three cases, and the 4–3–50 in two cases. The writers believe, however, that the 4–3–50 formula, which was not used in all the experiments in comparison with the 4–4–50, will prove the best for general use, in view of all the circumstances and the results thus far obtained.

GENERAL CONCLUSIONS.

When fresh stone lime is used in the preparation of Bordeaux mixture, as should always be done if possible, 3 pounds of lime will be ample to more than neutralize 4 pounds of copper sulphate, and since according to recent investigations already mentioned a great excess of lime is likely to prove detrimental rather than beneficial this quantity is preferable.

Of the mixtures other than Bordeaux which have been used, none has shown sufficiently good results to give promise of being a profitable substitute for it. Of such mixtures, neutral copper acetate gave the best results in Michigan, Mr. Giddings's vineyard, 1908, and also in New York in 1908. Neutral copper acetate solution also promises to be one of the most valuable fungicides for use as a final application when there is need of a nonstaining preparation. It will, however, be desirable to compare this carefully with the ammoniacal solution of copper carbonate to determine more accurately their relative value.

In nearly all of their experiments the writers have tried to determine the value of adding an adhesive preparation, or "sticker" as it is sometimes called. Resin-fishoil soap has been used for this purpose. The percentage of rot on the plots on which this was used has never been sufficiently reduced to justify the additional expense and trouble involved.

A study of the tables giving the results of the spraying experiments will show that where different numbers of applications were made in the same series, five applications made at the proper times gave nearly or quite as satisfactory results as six, seven, or even eight. Unless a vineyard has been neglected or rot has destroyed the greater part of the crop the preceding season, an application before the buds open, judging from the experiments of the writers, is not profitable; neither does spraying when the shoots are less than 6 inches long seem to materially improve the results.

Different forms of spraying outfits have been used in these experiments, as has already been pointed out. It is impossible to state that any one kind is best, as the conditions under which the work is to be done and other circumstances must always be taken into consideration. The writers have done very satisfactory work with geared traction outfits, with carbonic-acid-gas sprayers, and with gasoline power sprayers. It has been found necessary in some cases to modify the outfits somewhat, especially the arrangement and the number of the stationary nozzles.

In cases where the rot is severe and the season favorable for its development, in order to secure the most satisfactory results it is necessary to use trailers or long leads of hose which can be handled by persons walking behind the machine and directing the nozzles so as to thoroughly cover the fruit and foliage. This can not be done satisfactorily by stationary nozzles when the foliage is very heavy.

SUMMARY.

Bordeaux mixture prepared according to the 4–3–50 formula has been found to be as effective in preventing black-rot as the formulas in which larger quantities of copper sulphate and lime are used.

Five or six applications, beginning when the shoots were 8 inches to 1 foot long, gave generally as good results as when one or two additional earlier applications were made, showing apparently that no particular benefit is derived from dormant applications or from applications made when the shoots are less than 8 inches long.

Where unsprayed grapes were a total loss from black-rot in 1907 the rot on the sprayed plots was reduced to 28.3 per cent. The next season, 1908, when the rot was almost equally bad on unsprayed vineyards, the rot on the same sprayed plots was reduced to much less than 1 per cent, showing apparently the great cumulative effect of treatment for two seasons.

The gain due to spraying varied in the different vineyards, according to the severity of the rot, the number of sprayings, the productiveness of the vines, and the cost of materials and labor, from $10.60 to $62.30 per acre.

The experiments have shown the necessity of covering the vines thoroughly with a fine spray of properly prepared Bordeaux mixture. When the black-rot is serious or the foliage is very heavy it is necessary to use trailers and have the nozzles directed by hand, as fixed nozzles will not properly cover the foliage and fruit.

The tests of various lime-sulphur preparations have not yet been sufficient to determine their value as a preventive of black-rot.

Neutral copper acetate, 1 pound to 50 gallons of water, has been found to be the best nonstaining preparation tested in these experiments for final applications.

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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 156.
B. T. GALLOWAY, *Chief of Bureau.*

A STUDY OF DIVERSITY IN EGYPTIAN COTTON.

BY

O. F. COOK, ARGYLE McLACHLAN, AND
ROWLAND M. MEADE.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., May 8, 1909.

Sir: I have the honor to transmit herewith a paper entitled "A Study of Diversity in Egyptian Cotton," by Messrs. O. F. Cook, Argyle McLachlan, and Rowland M. Meade, of this Bureau, and recommend its publication as Bulletin No. 156 of the Bureau series.

This Bureau has conducted experiments with Egyptian cotton at Yuma, Ariz., for several years past, under the direction of Mr. T. H. Kearney. The results have been increasingly favorable. In the season of 1907 the cotton was so good, both in yield and in quality, as to justify our calling attention to this crop in Bulletin No. 128 of this Bureau as likely to prove suited to cultivation in the irrigated districts of Arizona and adjacent States.

In the season of 1908 the results were somewhat less favorable, though by no means discouraging. The planting of the cotton in other localities in Arizona and southern California showed that the acclimatization, which appeared to be well advanced at Yuma last year, is not sufficiently complete to insure normal behavior of the plants in other places. And even at Yuma the cotton of this season showed an appreciable deterioration, affecting the yield as well as the length and uniformity of the fiber.

As soon as these unfavorable tendencies became apparent Mr. Kearney asked that they be made the subject of special study to ascertain their nature and causes. Mr. Cook and his assistants were assigned to this work because they had become familiar with the behavior of cotton during the period of acclimatization, in connection with the weevil-resistant Central American cottons recently introduced into Texas. The present report contains the results of their investigations. It shows that the deterioration can be traced to the existence of several forms of diversity among the plants, and that cultural practices as well as factors of breeding and acclimatization must be taken into account in order to secure the necessary uniformity of the product.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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A STUDY OF DIVERSITY IN EGYPTIAN COTTON.

INTRODUCTION.

The diversity found in the Egyptian cotton in Arizona appears to be of four different kinds, evidently arising from different physiological factors. Precautions which may tend to avoid one kind of diversity will not be fully effective unless other factors are taken into account at the same time. Methods of acclimatization, breeding, and culture have all to be adapted to the special needs of the case if the full possibilities of the new crop are to be definitely ascertained.

The first and most striking kind of diversity is due to hybridization. The cross-fertilizing insects are much more abundant and active in our Southwestern States than in any other cotton-growing region thus far investigated. This will render it impossible to maintain a culture of pure Egyptian or other high-grade cotton unless all other kinds of cotton are excluded from the localities in which superior stocks are planted. Though the lint of the hybrid plants is often superior to that of the pure Egyptian plants, it is sufficiently different to interfere with the commercial uniformity of the product.

The second kind of diversity that affects the Egyptian cotton is evidently due to incomplete acclimatization. As with other types of cotton, transfer to new conditions induces great variation, not only in the habits of growth and other vegetative characters of the plants, but also in fertility and in the abundance and length of the lint. This form of diversity is to be eliminated by the selection each year of the plants that approach most nearly to the normal form of the variety, are the most fertile, and have the best lint.

The third kind of diversity is more directly connected with differences in the physical environment which cause or call forth differences in the individual plants. It is shown most strikingly in comparing the behavior of the plants in the different localities, but includes also some of the differences that occur in the same locality or in different parts of the same field. This form of diversity is familiar in all branches of agriculture, but is greater with a newly introduced variety, and may be expected to decrease as a better adjustment to the new conditions is attained. The second kind of diversity represents incomplete acclimatization, while the third kind is more closely connected with the phenomenon of accommodation.

The fourth kind of diversity is shown in the different parts of the same plant and is often very pronounced, especially in the characters of the lint. If the plants become too luxuriant, fruiting is deferred till late in the season or the early bolls remain poorly developed and produce a very weak fiber. To avoid this form of diversity, a proper relation has to be established between the habits of growth of the plants and the methods of culture and irrigation. Sudden changes in the rate of growth are particularly to be avoided as tending to produce fluctuations in the fertility of the plants and in the commercial quality of the lint.

The principal reason why diversity has such serious effects upon the yield of lint is found in the habit of the cotton plant to produce two types of branches which are quite distinct in form and function. Slight differences of external conditions which might have very little direct effect upon the size and vigor of the plant are able to induce relatively great differences in the yield by inducing a preponderance of the sterile, vegetative form of branches over the fertile form.

EGYPTIAN COTTON RELATED TO AMERICAN VARIETIES.

The cultivated varieties of cotton appear to fall into two series. Varieties native in America find their nearest relatives in other New World varieties, and all appear to be widely distinct from the indigenous species of Asia and Africa. Though very different from the Upland varieties of the United States, the Egyptian cotton and the Sea Island cottons are also native of tropical America and are not so fundamentally different from the Upland cottons as is often supposed.

No varieties have as yet been discovered which are exactly intermediate between the Egyptian and the Upland types, but many of the Central American and West Indian varieties which are obviously related to our Upland cottons show some of the characteristics of the Egyptian and the Sea Island series. At the same time it has been found that the West Indian and Central American relatives of the Sea Island and Egyptian cottons show many Upland characters. Only a little additional evidence is needed to prove that the native American types of cotton form a continuous series, without any larger breaks than those which serve to separate the very numerous local varieties still kept in cultivation among the agricultural Indians of tropical America. The results of the present study of diversity in Egyptian cotton tend to emphasize the relationships of the American varieties and make it evident that the Egyptian cottons have the same wide range of variation that other American cottons have been known to display.

NATURE OF DIVERSITIES AROUSED BY NEW CONDITIONS.

Transfer to new conditions has the effect of bringing back into expression many ancestral characters which do not appear when a variety is growing under conditions to which it is thoroughly accustomed. This tendency toward increased diversity under new conditions is not confined to cotton, but is widely prevalent among cultivated varieties of other plants. It is practically recognized in the fact, well-known among gardeners and florists, that the highest grade of seed of many varieties is produced only in the locality where the variety was developed. Everywhere else it appears to deteriorate by reason of the diversity that shows itself in the second or third generations, if not in the first.

The usual statement that the deterioration is due to unfavorable conditions is not a sufficient explanation of the diversity which often constitutes the deterioration. It is not reasonable to suppose that one set of new conditions can be directly responsible for the large number of differences that often appear. It is easier to believe that the new conditions are indirectly responsible for the diversity and that they bring it about by disturbing the heredity of the plants; that is, they disturb the internal adjustments which control the development of the individual plants and thus allow each of the individuals to develop in a different way, as they often appear to do. Even when a whole planting of a newly imported stock appears to change over to a new type quite different from the normal form in the previous environment a notable amount of individual difference is usually to be found, and this diversity may even appear to increase for two or three generations, or until the variety becomes readjusted to normal behavior under the new conditions.

That the new conditions are not directly responsible for the diverse characters that appear is also shown by the fact that different sets of new conditions often call forth closely similar examples of diversity. Different plantings of the same stock bring out the same series of diversities, and there is even a general correspondence between the ranges of diversity shown by different stocks. Features supposed to characterize only one variety are found to crop out in many related varieties. It becomes evident that the diversities, though they may be very extensive and very complex, are not entirely indefinite or at random but fall into parallel and related series, so that it is possible to think of the many newly aroused diversities as representing not new characters but returns to old characters, as though the new conditions had caused the plants to wander from their usual path of development and thus to fail to reach their normal goal.

DIVERSITY OF RECOGNIZED EGYPTIAN VARIETIES.

Varieties of Egyptian cotton seem to have been known chiefly by differences in the fiber rather than by differences in the plants. Though the Egyptian type of cotton as a whole seems to have a range of variation parallel to that of our Upland series of varieties, only a few varietal forms have been separated and given distinctive names. Much less attention has been given to differences in the vegetative characters of the plants than with our Upland varieties. The larger size and the more open habit of growth make it more difficult to become familiar with the vegetative differences in the Egyptian cotton than in the Upland cottons. In the smaller and more compact Upland plants individual differences can be seen and compared much more readily and are of the greatest assistance in acclimatization and breeding.

Unless we know the normal form of the plants as they grow under accustomed conditions we can not be sure that the selection that we apply to them is really calculated to favor the most prompt adjustment to the new conditions. In the absence of sufficiently definite knowledge of this kind, fertility and the characters of the lint are the only standards of selection that can be applied. If we select too narrowly we may preserve variant forms rather than the usual type of the variety, while if we retain good plants of many forms the intermingling of these may tend to prolong the condition of diversity.

A study of the range of diversity of the newly introduced Egyptian cottons was made for the double purpose of being able to judge of the extent of acclimatization and of securing a better basis for distinguishing hybrids. The same schedule or set of characters was used as a guide in the study of diversity in the plots raised from imported seed as was later employed in the study of the acclimatized stocks and the hybrids. The characters which received the most attention are indicated in greater detail in the latter part of the present report, where the hybrids are considered. The general plan of working with a series of the more definitely contrasted characters in mind had already been developed in the study of hybrids from the standpoint of the Upland types of cotton in Texas, and the work in Arizona was greatly facilitated by this preliminary practice.

It is not improbable, of course, that this method of procedure may have led us to overlook some forms of diversity that did not come within the range of our schedule of characters. On the other hand, it may be claimed that our work was able to give us more definite conclusions because the results of the study of diversity took a form which adapted them directly to the purposes of our inquiry.

DIVERSITY OF NEWLY INTRODUCED JANNOVITCH COTTON.

Fortunately for the purposes of the present study, plots of two of the most prominent commercial varieties of Egyptian cotton were grown this year at Yuma, Ariz., from newly imported seed obtained by Mr. David Fairchild, through the kindness of Mr. George P. Foaden, Secretary-General of the Khedivial Agricultural Society of Cairo, Egypt. A study of these plants has enabled us to gain an idea of the range of diversity which the Egyptian cottons are able to show before they have had an opportunity to be hybridized with Upland cottons in the United States. Doubtless these plants are more diverse than the same varieties would be under accustomed conditions in Egypt. A similar increase of diversity is known to take place in Mexican and Central American varieties of cotton when planted for the first time in Texas.

It has not been possible to find any single character in which the newly introduced Jannovitch cotton is uniform and constant. The habit of growth, the form and color of the leaves and flowers, the size and shape of the bolls, the fuzzy coating of the seed, and the length, strength, abundance, and color of the lint are all shown to be capable of pronounced variation.

Some of the plants had fertile branches near the ground, while on others all the lower branches were transformed into sterile "limbs" and produced no bolls or were only beginning to do so at the end of the season, near the top of the plant. The color and texture of the foliage vary considerably, some of the plants having a much lighter and more yellowish shade of green than the others. The lobes of the leaves are much longer and narrower on some plants than on others.

The flowers show a wide range of color. The prevailing tint is a rather deep, almost orange-yellow, though many have a lighter lemon shade and a few are pale and creamy, scarcely darker than those of Upland varieties and with the dark basal spots on the petals faint and broken, much as in hybrids with Upland cottons. And yet these pale-flowered plants showed no other approach to Upland characters.

The bolls vary in size and shape, some being rather short and rounded and others long and pointed and with the sides more or less flattened. The end may be drawn out into a distinct beak or may be abruptly shortened. The surface varies from a very dark blackish green to a much lighter green, more like that of the leaves and bracts. The oil glands which are scattered over the surface of the bolls also vary much in the different plants. Some bolls have very numerous small glands and others larger glands standing farther apart. The number of locks or compartments of the bolls varies from two to five. Two-locked bolls are not uncommon, some being present on nearly every plant. The great majority of the bolls have three locks, many of the plants having no bolls with four locks and many only a few. Five-locked bolls were found on one plant, although they were not supposed to occur at all in Egyptian cotton.

Some plants have the seeds almost completely naked, while others have them more than half covered with dense, closely adherent fuzz. The color of the fuzz also varies between a light seal-brown and a rather bright bluish green. Both the brown and the green fuzz may be combined with somewhat more woolly, whitish fuzz, especially at the upper or more rounded end of the seed. Seeds completely covered with white fuzz were also found in the original stock of seed imported from Egypt. These variations of the fuzz are of special interest in view of the fact that Egyptian cotton is sometimes supposed to have only smooth seeds, whereas completely naked seeds are very rarely found.

The lint varies in the different plants as much as any other feature. Not only the length, but the abundance, strength, fineness, and color of the fiber are subject to change. Some of the short lint is less than half the length of the longest; some of the seeds produce only half as much lint as others; some have the very strong lint for which Egyptian cotton is noted, while others have the lint so weak as to be almost worthless. Some have very fine, silky lint, while others have the fiber relatively coarse, coarser, in fact, than some of our Upland cottons. Some plants have lint as white as Upland cotton, while others show the distinctly pale brownish cast which is reckoned as one of the special characteristics of Egyptian cottons.

In addition to these more obvious differences, similar variations may be found in other details. Most of the plants have the calyx completely truncate or with scarcely appreciable, broadly rounded lobes, but some plants have the lobes more distinct and prominent. There is usually a rim of rather sparse hairs above the internal nectary of the calyx, though the hairs are sometimes lacking. The stigmas are usually very long and project far beyond the stamens, but in rare cases the stigmas are short and scarcely emerge from among the stamens, as in some of our Central American types. The stamens also vary considerably in number and arrangement. Instead of the usual compact mass of stamens arranged in five double rows there may be only a few stamens, and these may be widely separated in two groups or bands, one at the end of the staminal tube and the other near the middle, with an open space between. Three plants were found in the block of newly imported Jannovitch cotton which were well outside the range of diversity for the variety in having small white flowers, with petal spots pale or lacking altogether. These plants will be considered later in connection with similar aberrant plants which occurred in imported Mit Afifi cotton.

DIVERSITY OF NEWLY INTRODUCED MIT AFIFI COTTON.

Newly introduced Mit Afifi cotton, like the Jannovitch, showed a considerable range of diversity at Yuma in 1908, not only in the habits of growth, but more especially in the features of flowers, bolls, and lint. The plants are distinctly shorter on the average than those of the adjacent Jannovitch plot, but the diversity inside the varieties is too great to make it possible to distinguish any other obvious general difference between them. In other words, the characters of most of the Mit Afifi plants are not sufficiently distinctive to separate them from the Jannovitch if the two varieties were mixed together. Nevertheless the diversity of the Mit Afifi cotton seems broader than that of the Jannovitch, so that some of the plants might be recognized by distinctive features not shared with members of the Jannovitch series.

The habits of growth appear less diverse than several other characters. The plants are usually erect and from 6 to 8 feet tall. Some are prostrate, but these have merely broken over by the weight of the limbs and continue growing in a prostrate position. The prostrate plants are as long as those that have remained erect. Growing in the shade of the others the prostrate plants have large, dark green, crumpled leaves with broadly rounded lobes. The leaves of the upright plants have lighter shades of green; they are also more sharply lobed and smaller, with more even surfaces. The widths and lengths of the lobes differ somewhat among the upright plants.

The main axis is not well differentiated from the numerous long, upright basal limbs, which equal it in height. Usually the plants have three or four large limbs that rise from the lowest nodes, but some put out many more, and sometimes from nodes as high as a foot above the soil.

All fruiting branches are, as a rule, borne above the middle of the plant. There is only a slight difference between plants as to the height at which these branches begin to appear. In cases where the fruiting branches are from the lower nodes they are weak growths and retain very few bolls. Bolls retained on the lower branches are also undersized, as if they had been poorly nourished.

All plants agree in being practically devoid of hairs on all their parts. The veins of leaves and of bracts occasionally bear a few short, stellate hairs, but hairiness may be said to be lacking in Mit Afifi cotton.

The bracts differ widely. The usual type is rather long and slender, with short teeth. The three apical teeth grow from a median prolongation of the bract and stand apart from those on either side. The number of the teeth commonly varies from seven to eleven. Bracts can be found, however, which depart from all these typical characters. Thus there are broad, coarse bracts with teeth more pronounced and without the usual specialization of the apical teeth. Other bracts have the teeth notably reduced in size and in number. Some of the bracts become red when old or on exposure to the sun, but most of them remain light green.

Three features of Mit Afifi bracts appear to be nearly constant. The mature bracts have a stiff, brittle texture. The young bracts are not so stiff, but are smooth and shining. The second constant feature is the close appression of the bract to the bud and boll. The bracts of Egyptian cottons, unlike those of Upland varieties, have no distinct bulging at the base, no external indication of the place where the bract separates from the enlarged extremity of the peduncle. Instead of being deeply notched at the base, with the corners extending back on either side, as in Upland cotton, the base of the bract is more nearly a straight line, making the general shape of the bract triangular rather than cordate.

The calyx is normally longer than in Upland cotton, and has a nearly even, truncate margin, though variations are frequently met with. The calyx may be considerably shortened or may show broadly rounded and irregular lobes. Sometimes the calyx has a large lobe on one side, while the other side is correspondingly abbreviated. It has been observed by Mr. F. L. Lewton that the calyx of the Egyptian cottons does not fit so closely about the bases of the petals as in the Upland cotton. This permits a large species of carpenter bees to steal nectar from the Egyptian cottons without going inside the flowers.

The internal nectary of the calyx is usually accompanied by a rather indistinct band of hairs along its upper margin. The length and abundance of these hairs differ on different plants, while on a few the hairs are altogether wanting. Upland cottons have a very distinct ring of hairs surmounting the internal nectary, in some cases quite prominent.

The color of the flowers of Mit Afifi cotton is a bright lemon-yellow, with dark reddish purple spots at the base of the petals. Partial abortion or failure of flowers to open is frequent in Mit Afifi plants, though not found in Jannovitch. In the diversity of its flower characters the Mit Afifi cotton shows greater range than the Jannovitch. Few of the flowers are as deep a lemon-yellow as the deepest of the Jannovitch flowers and many are paler than the palest Jannovitch. The pale flowers of the Mit Afifi plants have about the same shade of color as the pale-colored flowers of Upland hybrids. The petal spots show considerable range also, from large or dark spots to small and light. One plant bearing deep yellow flowers had petal spots so faint as to be barely distinguishable. The shade of the petals and the depth of the color of the spot are not correlated in any way. The shade of purple in the petal spots is the same in the three imported stocks of Egyptian cotton growing at Yuma.

The petals of the Mit Afifi cotton usually appear somewhat shorter and smaller than those of the Jannovitch. The average length of the petals is about 2 inches, while the range is from 1½ to 2¼ inches. The style may protrude more than half an inch beyond the staminal tube or it may barely extend above the stamens. Stable Upland varieties do not show this irregularity, but as a rule this part of the pistil is consistently short. In Mit Afifi cotton grown for several years in Arizona the style is more uniformly short and thicker than in plants from newly introduced seed. No variation was detected in the color of the Mit Afifi pollen, which is a golden yellow.

One of the most distinctive flower features of Mit Afifi, as well as of Jannovitch cotton, is the arrangement of the stamens in five double series, which is apparent as one looks into the open flower. This appearance is due partly to the short staminal filaments. It occurs also in the Asiatic cottons which have similar short stamens. Opposed rows of stamens rising from each of the five ridges of the staminal tube lean toward each other to form the double series. This is not a constant feature in the Mit Afifi cotton growing at Yuma; some of the flowers have no indication of the arrangement of the stamens, though their stamens may be as short as in other flowers which have the feature well marked. In flowers of Upland cotton, where the filaments are much longer than in Egyptian, this arrangement of the stamens is never apparent.

Perhaps the greatest diversity in the imported Mit Afifi cotton appears in the shapes and sizes of bolls. The most common type is a well-filled boll 1½ inches long by 1 inch in diameter, with a rather blunt point. Some plants bear long, narrow, pointed bolls, while the bluntness of the usual type is occasionally exceeded by the very short, nearly spherical bolls found on some of the plants. The range of these boll characters is greater than in imported Jannovitch cotton, though the Mit Afifi bolls average shorter and thicker than those of the Jannovitch. The bolls are of a dark, shining green and are pitted with large black oil glands which lie close to the surface and deepen the dark green color. In rare cases the bolls are lighter green, with dull surfaces or with the oil glands somewhat more deeply buried under a layer of green tissue.

The predominant number of locks or carpels is three. The most frequent deviation from this is to the two-locked boll. Nine plants out of ten on which a census of the number of bolls and their locks was taken bore two-locked bolls, one plant having as high as 13 per cent of the two-locked bolls. A few of these had also one or two four-locked bolls, but it seems a general rule that when two-locked bolls are borne in any considerable numbers (15 per cent or more) it is to the exclusion of four-locked bolls, and vice versa. One plant had 33 per cent of four-locked bolls and no two-locked bolls. On the other hand, when the bolls of a plant are nearly all three-locked, both two-locked and four-locked bolls may be found in small numbers. The plant having the high percentage of two-locked bolls grew in the same row and next to the individual with the abundance of four-locked bolls. Diversity in this particular is evidently inherent in the plant rather than dependent upon differences in soil and moisture.

The lint varies to nearly as great an extent as the boll. The usual color is light buff. This is more constantly the case than in Jannovitch cotton, but many shades of buff are found; a few plants have the lint nearly white. The texture also varies from silky to harsh, the latter approaching the short-staple Uplands. The range of length is from 1 inch to 1½ inches, but the majority of plants have staple about 1¼ inches in length. In Upland cottons the fibers on different parts of the seeds are sometimes of different lengths. It is usual to find long fibers at the end of the seed and short fibers at the base, giving the "butterfly" appearance when the lint is combed out on the seed. The Mit Afifi seed may also bear fibers of different lengths, but the long fibers seem usually to come from the middle of the lint-bearing area of the seed and the short fibers from the extremities. The Mit Afifi seeds are never as well covered with lint as seeds of the best Upland cottons, the lower half or third of the seed often having no lint. There is also much difference in the quantity of fiber borne by seeds of different plants. Some have heavily linted seeds, while others have seeds nearly bare. The fibers are also much stronger on some plants than on others.

The seed of the Mit Afifi cotton usually has a tuft of greenish or brownish fuzz at either end, and the tufts are often connected by a line of fuzz along the ridge of the angled side. All degrees are found on the one hand between such seeds and those that are perfectly smooth or nearly so, and on the other hand the fuzz may be more abundant and longer, until a close likeness to the fuzzy Upland seed appears. The rounded surface of the seed, opposite the flat side, is least likely to become fuzzy, especially the portion of it near the base of the seed. Differences also appear in the color of the fuzz, some seeds showing more green than others, but green fuzz is not so noticeable as in Jannovitch seeds, a large proportion of which have bright green fuzz. The range of diversity in seed characters of Mit Afifi cotton grown in Arizona for a single season can hardly be said to be greater than in imported seed from which it is grown; the most that can be said is that the quantity of fuzz averages somewhat larger in the seed grown in Arizona.

Of the Mit Afifi seed imported in 1908 about 62 per cent had the usual fuzz tufted at both ends and sometimes extending along the raphe; in most cases the fuzz was green, though greenish brown and brown fuzz also occurred. About 6 per cent was naked or with only a minute trace of fuzz at the base. After the typical seeds and the naked seeds had been taken out the remainder were divided according to differences in the amount of fuzz into "nearly naked," "moderately fuzzy," "almost completely fuzzy," and "completely fuzzy." The first of these classes represented 21 per cent of the general total, and the other three classes, taken together, 11 per cent. Seeds that are completely fuzzy are represented by the smallest percentage—0.16 per cent. All these stages and degrees of fuzziness were found in seeds of otherwise typical shape, size, and color; that is, of a full oval or oval-pointed form, 9 mm. long, weighing 10½ to 11½ grams per 100, and of a uniform chestnut-brown color.

Though apparently independent of the amount of fuzz, many differences of shape, color, and markings could be found among the imported Egyptian seeds. About 25 per cent of all the imported seeds had longitudinal grooves for about one-fourth the distance or less from the base. These grooves were light colored, as if there had been checking of the surface as a result of shrinkage. Between the grooves the surface was black, darker than usual, and with a somewhat charred appearance. In a few cases the whole surface was checked or covered with a rough tissue like charcoal.

Some of the imported seeds were also aberrant in shape, size, or color. Some had very light or very dark seed coats, some were extra large, weighing 14 to 15 grams per 100, which is from 4 to 5 grams more than typical seeds, and others very small and weighing only 5½ to 6½ grams per 100. Long, flat, and round seeds were also selected. The long seeds were 1 mm. longer than the typical and with diameter much less in proportion to length than in typically shaped seeds. The flat seeds resembled apple seeds somewhat in shape and had the raphe along one edge. Blunt seeds, shorter than those of normal shape and for this reason more rounded, were described as "round." Altogether sixteen distinct seed types were selected for separate planting to determine whether any definite correlations exist between the characters of the seeds and the plants they produce.

While a considerable amount of this diversity among seeds has already been recognized in Egypt, it has not yet been found to be correlated with diversities in the plants, though it is evident from the reports of Mr. Balls that diversities are found in Egypt in the flowers, bolls, and lint very similar to those that have appeared in Arizona.[a]

ABERRANT TYPES IN IMPORTED JANNOVITCH AND MIT AFIFI COTTONS.

The most extreme forms of diversity in the plantings of imported seed were shown in a few plants that seemed to stand well outside of the general range of diversity of the varieties in which they appeared. Three cases of this kind were studied in the Jannovitch plot and three in the Mit Afifi. While there were notable differences between them, they had also a more general resemblance to each other than to the varieties in which they appeared. The flowers were in all cases of a very light creamy tint, the same as in our United States Upland varieties, and the petal spots were very faint or lacking altogether. The vegetative differences were much less conspicuous and might easily have been overlooked if the pale flowers had not drawn special attention to the plants.

The three Jannovitch plants represented two types. Two of these plants agreed in habits of growth and in flower characters. They displayed a more pronounced tendency toward branching at the base, and the long basal branches were unusually slender. The main axis was no stronger than the branches. The leaves of one plant were small and narrow lobed, while in the other they were large, slightly crumpled, and with broadly rounded lobes, the two extremes of Jannovitch leaves being represented by the two plants. The bolls, though of the usual dark, shining-green color, were unusually small and nearly round. In the number of their locks they did not differ from the other plants in the same block, one bearing 17 two-locked and 178 three-locked bolls, the other 4 two-locked, 170 three-locked, and 3 four-locked bolls. As in the case of the other Jannovitch plants grown from imported seed no fruit was borne below the middle of the plant. The bud and flower characters alone were the distinguishing features.

The bracts were small and quite distinct from Jannovitch cotton in shape and in the distribution of their teeth. They were frequently much broader than long, and with the margins evenly rounded; the teeth were small and uniformly distributed, without the separation of three at the tip of the bract common to Jannovitch cotton. The flowers behaved as though proterogynous, the stigmas protruding from the tip of the half-grown buds. This was due to the incongruous combination of the long Jannovitch pistil with very short petals, the petals being barely half as long as the average for the variety. In the open flowers the petals were about as long as the bracts and the stigma often extended beyond both, a very infrequent condition in cotton flowers.

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[a] Report of the Khedivial Agricultural Society for 1906, pp. 49 and 65.

On one plant the flowers had no petal spots and on the other the spots were barely apparent in some of the flowers. Such correlation of light petals and faint petal spots have been known to occur only in cases of hybrids; the palest flowers of normal Jannovitch cotton have petal spots as dark as those with darker petals. Nevertheless, there was no indication that this plant was a hybrid with an American Upland cotton. The usual correlation of characters common to Egyptian-Upland hybrid flowers—bell-shaped white flowers with sharply lobed calyx and long stamens with light-colored pollen—did not occur in this white-flowered Egyptian plant. The pollen was as yellow as in typical Jannovitch cotton and the stamens were even shorter than usual for this variety.

The lint of one plant was nearly white, while that of the other was light buff. In both cases it was of good length and quality and of medium strength, the buff lint being stronger than the white. On the plant bearing white lint, only one or two seeds developed in a lock. Furthermore, these seeds sometimes failed to turn black.

The third of the diverse Jannovitch plants, representing the second type, was like the other two in approximating the Egyptian style of growth and foliage. The limbs were more spreading than usual and the leaves lighter green. In other respects it differed as widely from the other white-flowered Jannovitch as from the normal Jannovitch cotton. The bracts were of stiff Jannovitch texture, but were broad and cordate. The flower was about the size of the normal Jannovitch flower, but pale, with pale red spots. The calyx was sharply lobed, one or two or the lobes being greatly elongated. The internal nectary bore a distinct band of long, abundant hairs. The bolls were light green, larger than Jannovitch bolls, round, with a prolonged beak. Of the bolls 74 were four-locked, 23 three-locked, and 7 five-locked. The lint was tinged with buff and was abundant, short, and silky. The seeds were more nearly round than in normal Jannovitch cotton, and even larger than in American Upland varieties. Many of them were about two-thirds covered with a dense, green fuzz. Others were not so fuzzy, but all bore more fuzz than is usual for Jannovitch cotton. The naked surfaces of the seeds were black and irregularly pitted.

The three aberrant white-flowered plants in the block of newly introduced Mit Afifi cotton resembled the two already described as the first type in Jannovitch. In all but flower and boll characters these plants were indistinguishable from the normal Mit Afifi cotton. The flowers were white in all three cases and had no petal spots. The petals were much smaller than the average for Mit Afifi. The flowers differed from those of the similar type in Jannovitch plants in not being proterogynous. Though the petals were short the pistil was likewise abbreviated; even in the open flower the pistil did not extend beyond the petals as in Jannovitch cotton. Differences only slightly marked in normal plants of the two varieties were accentuated in these white-flowered types. In all the white-flowered Mit Afifi plants the style protruded but slightly beyond the stamens, while in the Jannovitch plants the corresponding portion of the style was very long. The staminal tube of the white-flowered Mit Afifi plants was constantly longer than in the Jannovitch cotton. This accounted to some degree for the shorter extension of the style beyond the staminal tube in the Mit Afifi cotton, though the style is absolutely shorter in this variety than in Jannovitch. The point of origin of the staminal zone was higher above the base of the flower in Mit Afifi, and the zone itself was longer than in Jannovitch cotton.

The white-flowered Mit Afifi plants differed further from the two similarly aberrant Jannovitch plants in having a faint hairy rim above the internal nectary of the calyx. There was also a much larger percentage of four-locked bolls than in the aberrant Jannovitch plants, and two of the three plants bore a few five-locked bolls. The shapes of the bolls of the white-flowered Mit Afifi plants were diverse, varying from round to blunt-oval. There were also differences in size, the largest being 1⅝ inches long by 1⅛ inches in diameter. On one plant the bolls were light green and lacked the shining smoothness of surface usual in Mit Afifi cotton. Similar diversities in boll characters did not appear among the white-flowered Jannovitch plants.

One of the three Mit Afifi plants showed great degeneracy. Very little fruit had been retained, though the flowers were produced in normal abundance. The few bolls that reached maturity had sunken carpels and only one or two poorly linted seeds.

HYBRID NATURE OF THE ABERRANT JANNOVITCH AND MIT AFIFI PLANTS.

In some particulars the white-flowered Mit Afifi type is intermediate between the two Jannovitch types. In style of growth and in flower characters the white-flowered Mit Afifi plants are close counterparts of the first of the white-flowered Jannovitch types, except that they bear five-locked bolls like the second Jannovitch type. Their resemblance to the first type in Jannovitch is so marked that a similar foreign influence is naturally to be suspected.

But if hybridization is responsible for the diversity it also seems probable that the cross is of long standing. The preponderance of the Egyptian characters is large and the lint averages the same as that of normal plants except in a single individual. Two of the white-flowered plants in the Jannovitch plots and the three in Mit Afifi differ less among themselves than do many of the normal plants of these varieties. Furthermore, indistinct varietal characters of normal plants are consistently accentuated and made prominent features of the aberrant plants, as often occurs in hybrids.

The combinations of characters found in the Jannovitch plant that gave the strongest indications of hybridity differ sufficiently from those observed in the known Egyptian-Upland crosses to make it reasonably certain that the source of contamination was not American Upland cotton, but seem to indicate that the foreign parent resembles Upland to some extent. The correlations of flower characters are the same as those that appear very frequently in the Egyptian-Upland hybrids. The petals are white, the petal spots faint, the calyx lobes pronounced, and there is a distinct hairy rim above the internal nectary.

The accentuation of the lobes of the calyx to such an extent as in one of the suspected Jannovitch hybrids finds no counterpart in the several generations of Egyptian-Upland hybrids which have been studied, and this plant also bears five-locked bolls with large, green-fuzzy seeds and short lint. The peculiar rounded shape of the seeds and their large size and partly naked, rough surface do not correspond with anything found among plants known to be Egyptian-Upland hybrids.

Considering the white-flowered Egyptian plants as hybrids, the most probable source of infection seems to be the "Hindi" cotton, an inferior, white-linted type not now planted in Egypt, but which persists as a weed and mixes with the Egyptian cotton to the great detriment of the fiber, as several investigators have reported. The Hindi cotton has white flowers without petal spots, and five-locked bolls, characters which in the plantings of newly imported Egyptian cottons at Yuma were peculiar to the aberrant plants alone. At the same time these plants do not have seeds like the Hindi cotton, which are said to be long, narrow, and free from fuzz, and thus easily recognized. A considerable effort has been made by the Khedivial Agricultural Society, of Cairo, to eliminate the Hindi plants by culling out the seeds from the commercial varieties, Mit Afifi in particular. Even in the best samples there is said to be an admixture of 2 or 3 per cent of Hindi seed.[a]

This precaution has not been found adequate to eliminate all the plants with Hindi characteristics, which makes it evident that the

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[a] Foaden, George P., secretary-general of the Khedivial Agricultural Society. "The Selection of Cotton Seed," in Yearbook of Khedivial Agricultural Society for 1905.

Hindi peculiarities of the seed are not always obvious. This has also been appreciated in Egypt, as the following statement [a] will show:

> Finally, I may say that even in fields which have been picked free from Hindi, both on the seed tables and at thinning out, I have this year found a large percentage of plants bearing one or more inconspicuous Hindi peculiarities shuffled into the pack of Afifi characteristics.

It is evident from this statement that the only method of keeping the undesirable Hindi characteristics in abeyance is to maintain a still more efficient selection, based on more general knowledge of the characters that enable the Hindi hybrids to be detected.

MIT AFIFI COTTON MORE DIVERSE THAN JANNOVITCH.

While the plots of newly introduced Jannovitch and Mit Afifi cottons at Yuma fall far short of the standards of uniformity usually applied to Upland varieties, it seems that Jannovitch cotton approaches this standard more nearly than does the Mit Afifi. The flowers of Jannovitch plants are darker yellow and show less variation of color than do the flowers of Mit Afifi. The basal spots of the petals likewise are nearly always large and dark in Jannovitch plants, while in Mit Afifi there is more variation and all degrees from very dark to very pale spots. The portion of the pistil extending beyond the staminal tube is longer and more constant in length in the Jannovitch cotton. Only a few plants are found with the pistils abbreviated, a condition of rather frequent occurrence in Mit Afifi. The Jannovitch cotton also has a more regular form of boll, long and pointed, about 1$\frac{5}{8}$ inches in length by 1 inch in diameter. Blunt bolls are sometimes found, but the range of diversity is not so wide as in Mit Afifi. Here the usual shape is rather blunt, with an abrupt, short point, but some of the Mit Afifi bolls are even more pointed and narrower than those of the Jannovitch cotton.

DIVERSITY IN THE DALE EGYPTIAN COTTON.

A third type of Egyptian cotton planted at Yuma was the Dale, a variety of unknown ancestry only recently brought forward in Egypt and now planted for the first time in America.[b] It differs from both the Jannovitch and the Mit Afifi varieties in peculiarities of its vegetative characters and habits of growth, quite as marked as the vegetative characters that distinguish Upland varieties. The range of diversity is also much greater than in the other Egyptian varieties, and in some respects is fully as great as would be expected in a series of hybrids.

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[a] Balls, W. Lawrence. "Seed Selection," in Yearbook of the Khedivial Agricultural Society for 1906, p. 81.

[b] Grown from seed sent to the Department of Agriculture by Mr. Alfred Dale, Mansurah, Egypt, with the following remark: "A special quality I have cultivated on my farm for the past year, which has given splendid results both in quality and quantity."

Many of the plants have abnormally short fruiting branches like the "cluster" varieties of the Upland type. The bolls are often borne on very long peduncles and in clusters of three to six, or even more. The plants which bear their bolls in this manner are tall and spike-like, with coarse, dark foliage, characters also frequent in Upland cluster cottons. Other tall plants bear their bolls only at the ends of the branches, but not in clusters. Still other plants, including the tallest of all, are completely sterile. All the tall plants have long basal limbs, but the main axis is always strongly developed. A fourth style of plant is more nearly like the Upland, with normal fertile secondaries and bearing some of the fruit below the middle of the plant. This type of plant also resembles the Upland in bearing five-locked bolls. Indeed, it appears that five-locked bolls are of more frequent occurrence in the Dale type than are two-locked bolls, though plants bearing two-locked bolls also occur. The two-locked bolls were found on two small plants of a type rather aberrant in other respects. One of them had perfectly smooth seeds and very sparse, weak lint. The majority of the plants bear three-locked and four-locked bolls, the three-locked bolls being predominant. The locks were counted in the bolls of twelve plants and the percentage of four-locked bolls was about 15.

The range of diversity in the size and shape of bolls is much greater than in the other Egyptian varieties, and this is true also of flower characters. Large and small flowers, lemon and cream colored petals, and dark and pale petal spots are all represented in the planting. Even in the same flower the petal spots may range from dark to very faint on the various petals.

The bracts do not resemble those of the other Egyptian cottons, but are broad (some broader than long), more strongly laciniate, with the laciniæ longer and broader than in Jannovitch or Mit Afifi cotton and without the Egyptian arrangement of three laciniæ at the apex of the bract. There is also a notable frequency of abnormal bracts intermediate in form between ordinary leaves and fully specialized bracts. This series of abnormalities has a botanical interest in affording apparently conclusive evidence of the nature of the modifications that have been made in specializing leaves into bracts. The stipules become greatly enlarged, the blade correspondingly reduced, and the petiole eliminated entirely. The three large teeth in the middle of the bract represent the lobes of the leaf, the other teeth being borne on the enlarged stipules. The nectary at the base of the bract corresponds to the nectary on the midrib of a normal leaf.

DIVERSITY IN LATER GENERATIONS OF MIT AFIFI COTTON.

Experiments with recently introduced Central American types of cotton have made us familiar with the fact that an even greater amount of diversity is often shown in the second and third generations than in the first, depending upon the extent to which the characters of the variety are disturbed by the transfer to new conditions.

That the total diversity should be greater in the second generation of a stock than in the first generation is easily to be understood from the fact that the seeds which produce the second generation must develop under the new conditions, whereas those which produce the first generation have been developed under conditions normal for the variety. A variation that takes place in a seed or a seedling is to be compared with the variation of a bud or branch rather than with the variations that occur when new conjugations take place.

That new conditions are even more likely to disturb the processes of heredity at the time of seed formation than during the previous period of vegetative growth is shown by the many instances of carefully selected varieties of vegetables and flowers which will produce one generation of normal plants under new conditions, but show marked diversity and deterioration in the second generation. Some of Mr. Kearney's special selections from individual plants have attained a uniformity notably greater than that of the new plantings of the Egyptian varieties, but in the bulk plantings, and especially in plantings made under conditions different from those in which the original breeding was done, a wide range of diversity is still to be found, in some respects even wider than in the plats raised from the newly imported seed. Nevertheless, it does not appear that this persistence of diversity is in the nature of a failure of acclimatization or that it indicates any special resistance to acclimatization on the part of this type of cotton.

The effect of the selection thus far applied can be fairly judged only by the selected stocks themselves, which are often very uniform. Apart from hybrids the diversity of the bulk plantings is largely explained by the diversity between the various selections whose seeds were combined in the bulk plantings. Considerable diversity could be ascribed very properly to the mixture of the seed of the different selections and the crossing of the selections among themselves. Indeed, it is a more difficult problem to explain the uniformity of the selections, unless we consider that some of them represent mutative variations which are sometimes notably prepotent and constant in their progeny even when freely exposed to crossing with the parent form.

The fact that the Arizona-Egyptian plants were grown in large numbers and in several different localities under different conditions would also tend to increase the impression of diversity by giving more numerous opportunities for differences to appear. Finally, the presence of numerous and diverse Upland hybrids would itself tend strongly to establish an impression of diversity, even if the Egyptian plants themselves were more nearly alike than they are.

Differences in fertility, rather than in other special characteristics, is the most serious form of diversity and that which shows most definitely that acclimatization is still incomplete. Inequalities in the yield and the quality of the lint are frequently out of all proportion to any differences of natural conditions reflected in the stature or apparent vigor of the plants. This form of diversity was found to depend on the fact that the cotton plant bears two distinctly specialized kinds of branches, one fertile and the other sterile, as will be explained in later chapters.

DIVERSITY AFFECTED BY METHODS OF BREEDING.

The practical work of acclimatizing a foreign variety like the Egyptian cotton consists simply in the selection in each season of those plants that behave in a normal manner or in a manner which most nearly approaches the normal. The primary object of acclimatization is not to change or improve the variety, for which selection is often used in other cases, but to preserve the variety and rescue it from the agricultural deterioration which results from too great and indiscriminate diversity. Instead of attempting to bring about changes of characters our efforts are directed toward securing greater stability in the expression of the characters.

Even without any special selection there is often a distinct tendency to return toward the normal adjustments. Even when the first generation of a newly introduced cotton is nearly sterile each succeeding generation tends to be more fertile and productive. Nevertheless, it is hardly to be expected that there would be any complete return of the variety to its normal characters without the assistance of selection. The diversity which the new conditions arouse may be thought of as representing the same diversity that was suppressed when the variety was originated by selection. The new conditions having disturbed the adjustments and released the old diversity, a new selection is required to restore the previous uniformity, that is, to separate again the lines of descent that have the strongest tendency to express the desired set of characters.

The process of acclimatization in the strict sense would be finished when the variety had been restored to a condition of stability, so that crops as normal and uniform as those of other varieties that are being planted in the same region could be raised. This has been accomplished in Texas with several strains selected from Central American stocks introduced four years ago.

The diversity aroused by the new conditions is likely to afford novelties which attract the interest of the breeder and furnish him very promising material for the development of valuable new types. Some of Mr. Kearney's best selections show vegetative characters quite different from the average form of the Egyptian plants and apparently quite superior. At the same time it has to be considered that the behavior of these new types may not be quite the same as if the normal, typical form of the parent variety had been retained. Among the Central American varieties at least, those strains seem to be most promptly acclimatized which are nearest to the ordinary form of the parent stock as it grew in Central America. Selections of such individuals often yield a very uniform progeny, whereas selections of other types continue to show a larger amount of diversity. Such instability may be compared to the instability of hybrids, in that the forms secured in this way represent new combinations of characters, or at least unaccustomed combinations. It is easy to understand that such new combinations may be less stable and less promptly reduced to uniformity than combinations that have been expressed with regularity for many generations.

Not only is there a distinction to be drawn between acclimatization and breeding, but a practical difference of methods may need to be used, at least in the case of cotton. If selections were kept inside of the varietal type and had only the minor fluctuating differences in degrees of fertility or lengths of lint, crossing between these selections might have no serious effect in retarding acclimatization. But where each selection is likely to represent a diversity equivalent to a distinct variety, the crossing of such selections may prolong the condition of instability, if it does not have a further tendency toward a deterioration or mongrelizing of the type. Free crossing among numerous varieties of the same species often leads the composite group back to the characters of the wild type and may produce a serious deterioration, particularly when the characters of the varieties represent the results of special selection.

The bearing of these facts upon the problem of acclimatizing the Egyptian cotton is not difficult to understand. To secure the most rapid progress of the work of acclimatization it ought to be considered as entirely distinct from the work of securing improved types of Egyptian cotton. The selections for these two purposes should be conducted on separate lines and by different methods. The diverse forms, whether superior or not, should be removed from the stock that is being acclimatized. The normal form and habits of growth, combined with the normal fertility and the lint characters, should constitute the standards of selection, if prompt acclimatization and attainment of commercial uniformity are the principal objects. The development, testing, and substitution of new and improved types may be considered as representing a later stage in the development of an established industry. Even though distinct improvements can be made later on, it is likely to be an advantage to begin with the nearest possible approach to methods already tried and to products already in demand.

RELATION BETWEEN DIVERSITY AND EXTERNAL CONDITIONS.

It is a most familiar fact that plants of the same kind will show different characteristics when grown under different conditions. This power of the plants to adapt themselves to different conditions is very important in an agricultural species or variety if it is not to be restricted to one locality or set of conditions. Cotton is one of the most adaptable of plants, able to thrive and produce an abundance of seed under a very wide range of natural conditions, and able to make notable changes of form and habits of growth in accord with the needs of many different surroundings.

Nevertheless, this readiness of adaptability is not without its disadvantages, especially in such a plant as Egyptian cotton, where the uniformity of the product is quite as important as the amount of the yield. In changing the characters which have to be varied for the sake of adaptation to different external conditions, other characters are likely to be changed or to fall out of adjustment. Each fully developed plant represents a balanced combination of many characters.

Selection is our means of compelling a variety to repeat the particular combination of characters that we desire, but the adjustments established by the selective breeding of a variety under one set of conditions are often lost or diminished when the plants are transferred to a new set of conditions. Though new conditions may be equally favorable, or even more favorable, the close adjustment of the varietal characters are likely to be disturbed whenever there are any changes or substitution among the characters which are affected by the external conditions. Even when a variety continues to be grown in the same place, seasonal differences of temperature and rainfall are often sufficient to disturb the adjustments of the characters, so that different years may bring great differences in the uniformity of the same crop.

The experiments with the Egyptian cotton at Yuma and at Sacaton may be viewed as an example of such a loss of adjustments. The natural conditions at Sacaton did not appear to be less favorable than at Yuma as far as they could be judged by the size and productiveness of the plants, nor did the total amount of diversity among the plants appear to be greater at Sacaton than at Yuma. Nevertheless, the effects of the selection for long lint which have been made at Yuma were notably less apparent at Sacaton. Very few plants, if any, showed as long lint as many of the better selections at Yuma. Most of the Yuma plantings had the advantage of an additional year of selection, which might have been expected to have a favorable effect upon the average of the lint, but can hardly be thought to explain the almost complete failure of even individual plants at Sacaton to attain the Yuma standards. Further experiments must determine, of course, the extent to which this difference represents a phenomenon of acclimatization. It is possible that the Sacaton conditions may be less favorable to long fiber than those at Yuma, but the general behavior of the plants does not lead us to expect any permanent difference of this kind.

This relative inferiority of the Egyptian lint at Sacaton made the hybrids appear more definitely superior to the pure Egyptians than at Yuma, though there was no indication that the Sacaton hybrids were really better than the Yuma hybrids. They seemed in fact to be not quite as good, and yet they gave a stronger impression of superiority over the pure Egyptians.

In this particular case the transfer of the plants to new conditions appeared to shorten the range of diversity rather than to increase it, there being less of the long lint shown at Yuma. But if acclimatization had been complete at Yuma, so that the long lint had become a more uniform character, the transfer to Sacaton would doubtless have caused the diversity to appear greater by allowing many of the plants to fall back to the short lint, after short lint had ceased to appear at Yuma.

IMPORTANCE OF HABITS OF BRANCHING.

The most marked effects of different conditions of growth are exerted through their influence upon the methods of branching. The branches of the cotton plant are of two definitely different forms.[a] Fertile branches are horizontal or drooping. Each joint bears a fruit bud, and the internodes are twisted to bring the buds to the upper side. Sterile branches, or "limbs," are upright or ascending, with long straight joints and no fruit buds. The sterile limbs are to be thought of as subdivisions of the main stalk and have the same function. Like the main stalk they can produce other branches which are fertile, but are themselves unable to set any flowers or fruits. If all of the lower branches are of the sterile, upright form the flower buds can not begin to form till the second generation of branches has been put forth. This delay contributes to the lateness of the crop, which is usually reckoned as a characteristic of the Egyptian type of cotton.

Nevertheless it appears that in Arizona, at least, heavy yields depend largely upon the size of the contribution made by the fertile branches formed on the main stem within 2 or 3 feet from the ground. The plants seldom attain any satisfactory degree of fertility unless they begin by putting forth many of the short horizontal fruiting branches from the lower part of the main stem. Reference to Plates I and II will enable the reader to gain an idea of the intimate relation between fertility and forms of branching.

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[a] In view of the practical importance of recognizing the two distinct kinds of branches, it may be well to add a summary of facts stated in a former publication. (Weevil-Resisting Adaptations of the Cotton Plant, Bulletin 88, Bureau of Plant Industry, pp. 19 and 20.)

Two buds are formed at the base of each leaf of a cotton plant. The bud that comes from the middle of the base or true axil of the leaf grows into a vegetative branch, never into a fruiting branch. These vegetative, axillary, or primary branches are like the main stem in that they produce fruiting branches, but they never produce directly any flower buds or bolls. The fruiting branches, as well as the flower buds they bear, arise in an extra-axillary position at the right or the left side of the true axillary bud. Thus each cotton stalk or vegetative branch is either right-handed or left-handed with respect to the arrangement of the fertile branches, conforming to the direction of the spiral in which the leaves are inserted.

External conditions may affect the development of the branches in two principal ways—by inducing the formation of an abnormal number of primary branches or by leading the secondary branches to behave like primary branches. Although axillary buds do not produce fruiting branches the extra-axillary branches often assume the form and behavior of vegetative branches. It is the regular habit of some types of cotton to keep the axillary buds in a dormant condition and to form vegetative branches by vegetative transformation of fruiting branches. After this change takes place there is no return to the fertile form. A branch that begins to grow without producing flower buds on the basal internodes never produces any flower buds. Unless branches of the fruiting type are formed no flower buds can be put forth and the plant remains completely sterile, no matter how large and luxuriant it may be. (*O. F. C.*)

If the plants have too strong a tendency to vegetative growth early in the season too many of the branches take on the sterile form. (Pl. I, fig. 2.) The plant may then fail to develop any of the lower fruiting branches or may leave them small and stunted. (Pl. I, fig. 1.) And even after a promising development of the fruiting branches has taken place and goodly numbers of bolls have been set, they may fail to attain a normal growth if the plant falls later on into the condition of too great vegetative luxuriance. Not only is there a cessation in the formation of more bolls, but even those that are already formed may shrivel and drop off, or may be able to form only abnormally short and weak lint. This direct evidence of the change of the plant's activity from the reproductive to the vegetative side is very common. Sometimes all the bolls of the lower part of the plant are inferior, and sometimes the lowest are notably better than those farther up, which could not have been so far advanced when the change of tendencies took place.

The unusual liability to change greatly intensifies the influence of the external conditions in determining the fate of the individual plants. A plant whose characters are more stable may resist all the influences that upset its less stable neighbors, which may yield to the disturbing influences at different stages of development, depending upon their different degrees of adjustment.

The fact that so many of the plants show normal tendencies of growth in the early part of the season indicates that high temperature is one of the decisive factors, but it is evident that conditions of soil and water supply are often very important in assisting or hindering the change. Rich soil and abundant water predispose the plants to greater luxuriance, while poorer and drier soils tend to hold them back, and thus favor greater uniformity. In the drier parts of the fields at Yuma all the plants (even including the hybrids) appear much more alike than where moisture is abundant. Thus it is probably an aid to acclimatization to keep the plants as far as possible under moderate conditions, to avoid an unnecessary intensification of the instability, and yet to allow the unstable plants to show themselves and be weeded out.

It might be argued that selection will be more efficient if the plants are placed under extreme conditions, so that their powers of maintaining the normal adjustments of their characters may be tested more thoroughly. The danger is that all of the plants may be changed beyond the range of normal behavior, and that this may increase the difficulty of bringing even the best selections back to a condition of practical uniformity. When the changes are too great and too general it also becomes more difficult to tell whether some plants are more normal than others. The plants that prove to be the most fertile in the first seasons, when the work of acclimatization is carried on under extreme conditions, do not necessarily represent the best types for agricultural purposes.

The fact that the condition of the Egyptian cotton, with reference to fertility and acclimatization, can be determined from the way in which the branches develop in the early part of the season shows that this feature is of great practical importance. And after acclimatization has been accomplished the development of the fertile branches will be the chief issue with the farmer. Their behavior, more than anything else, will influence the choice of methods of culture as well as the times of planting and irrigation. It is already apparent that the application of too much water at the wrong time may not only diminish the crop but may actually injure the growing bolls.

Though writers on the behavior of Egyptian cotton in Egypt do not seem to have recognized the different types of branches and their relation to external conditions, they have not failed to report that too much vegetative vigor has an adverse effect upon the crop.

> It is noticeable that, speaking generally, the best lint from the cotton grader's standpoint is not produced by the largest and strongest plants, so that in popular expression "running to wood" is objectionable. * * * The provinces of Menoufieh and Gharbieh produce the best cotton in the country, though the climate is less suited to mere growth of the trees than in those provinces which lie farther south. * * * A similar result, though the operating cause is apparently different, is obtained by the "Sea Island cotton" growers in America, who apply salt marsh mud to their crops. This apparently acts by checking root absorption and consequently growth.[a]

Further indications of the methods used in Egypt to hold the vegetative growth in check and induce earlier fruiting have already appeared in a bulletin of this Bureau.

> There has been during recent years a distinct tendency toward early planting, it being contended that during a series of years the largest yields, as well as the best qualities, are produced by early planters.
>
> Early-planted cotton grows more regularly and evenly and does not tend to produce such coarse growth (weed) as that planted later. It also branches better from the bottom.
>
> It is generally accepted that as long an interval as is consistent with the health of the plant should elapse before the first watering is given; otherwise the plant is not encouraged to root well, but tends to grow too rapidly. Too frequent waterings during the early growing period prevent the proper branching of the plants from the bottom. They grow too rapidly, producing their forms at the top rather than from the bottom, and are spindling.
>
> The basis of the mixture of chemical manures employed is superphosphate. * * * It checks the tendency to coarse growth and thus encourages ripening, while it greatly improves the quality of the fiber.

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[a] Balls, W. Lawrence. Yearbook of the Khedivial Agricultural Society for 1906, pp. 38–39.

The use of fresh stable manure causes rank growth, late maturity, and an inferior fiber.[a]

The same difficulties have been recognized among the planters of Sea Island cotton, and the measures of prevention used by them have been noticed in another publication of this Bureau.

This ridge system gives better results in two classes of cases, as follows: * * * (2) When, on account of the land being rich and well fertilized, Sea Island cotton grows too much to weed under level culture. In such cases the grower is compelled to adopt measures to turn the energies of the plant from vegetative growth to fruiting. This is done by restricting the root development, (1) by maintaining a compact subsoil, which the Sea Island planters accomplish in their deep, sandy soils by pasturing with cattle during the year of rest; (2) by regulating the moisture supply by the high beds; and (3) by root pruning by deep cultivation if the cotton needs it.

It is advised that planting be begun as early as the season permits. This varies in different years and sections from March 15 to April 10. Early-planted Sea Island cotton is found to make a more compact and fruitful plant, while late cotton tends to form a larger and coarser weed.[b]

DIVERSITY AFFECTED BY DIFFERENCES OF LOCAL CONDITIONS.

From indications already given regarding the nature of the diversity of the newly introduced varieties it is easy to understand that they are especially susceptible to the influence of adverse conditions. Inequalities of soil or water supply which would affect thoroughly acclimatized varieties only to the extent of making the plants a little larger or smaller may disturb the adjustments of other characters in a partially acclimatized stock and bring about serious deterioration.

Many striking illustrations of this were found at Sacaton, where series of good and fertile plants would often be succeeded in the same row by considerable numbers of others which were notably inferior and unproductive. The definite groupings of the good and bad plants made it evident that something in the soil or water supply must have been the exciting cause of these differences. The inequality might have been extremely slight and temporary, but it was evidently sufficient to start the plants on different courses of development. That the change so generally affects the quality of the lint is not surprising if we consider the fact that the long lint of the Egyptian cotton is a highly specialized character likely to be affected by any disturbance of the process of development, whether by external conditions or by other forms of variation.

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[a] Foaden, George P. Notes on Egyptian Agriculture, Bulletin 62, Bureau of Plant Industry, U. S. Department of Agriculture, 1904, pp. 22–24, 28.

[b] Orton, W. A. "Sea Island Cotton: Its Culture, Improvement, and Diseases," Farmers' Bulletin 302, U. S. Department of Agriculture, pp. 24 and 25.

That otherwise imperceptible differences of conditions in the same fields have been able to exert such notable effects upon the cotton plants affords additional testimony to the fact of instability. It appears more reasonable to believe that the general shortening of the lint at Sacaton may be largely due to the change from Yuma to Sacaton rather than to any directly unfavorable factor in the natural conditions at Sacaton that will prevent the production of longer lint in future years.

A similar deterioration has been observed in Texas, even in the standard varieties of Upland cotton, when carried to different localities. Thus the Triumph cotton bred by Alexander Mebane at Lockhart, Tex., showed notably greater diversity and a lower average in lint when first taken to a higher elevation at Kerrville, Tex. That this deterioration represented the result of the change of conditions rather than of essentially unfavorable conditions was shown by experiments made at the same time and place with plants of the same stock, but raised from seed of normal plants grown at Kerrville in the previous year. The second generation plants were notably superior to those raised from the new Lockhart seed. In a series of such experiments the differences in yields ran between 10 and 20 per cent in favor of the second plantings of the same stocks over first plantings. The improvement in the quality of the lint was even greater.

DIVERSITY IN EGYPTIAN-UPLAND HYBRIDS.

To judge of the degree of acclimatization that has been attained as evidenced by the present extent of diversity in the Egyptian cotton is rendered much more difficult by the presence in the fields of many hybrids between the Egyptian cottons and various Upland varieties. These hybrids not only afford endless gradations and combinations of the parental characters, but the characters are often exaggerated in the hybrids and carried beyond the extremes of the parental types. Primitive characters not commonly represented in the parent stocks may also be brought back to expression in the hybrids.

Instead of being intermediate in size between the large Egyptian and smaller Upland plants the hybrid plants are usually much larger than the Egyptian. The seeds of the hybrid may be larger than those of either parent and they may be more fuzzy than the Upland parent or more completely naked than those of the Egyptian. The most important feature of all, the lint, does not obey the customary rule of intermediate expression of parental characters. Instead of the long Egyptian lint being shortened by combining with the short-linted Uplands there is usually a definite increase in length and strength, especially in the first and second generations. This superiority of the fiber of the hybrids was readily appreciable in the general field plantings, especially at Sacaton, but was less pronounced in the specially selected stocks at Yuma.

The notable superiority of the lint of hybrids over that of pure Egyptian plants is one of the most interesting facts established by the present study of diversity. Together with the problem of learning how to prevent and eradicate the hybrids, we have also to consider the still more interesting and important possibility of learning whether superior hybrids can not be grown in regular commercial quantities and utilized as a practical means of producing cotton of very high quality.

FREQUENCY OF CROSS-FERTILIZATION.

The experiments with Egyptian cotton in Arizona confirm the results of our Texas experiments in showing that cross-fertilization takes place in a much larger proportion of cases than previous writers on the subject have supposed. The large, showy, open flowers of the cotton plant invite the visits of insects, so that a large amount of cross-fertilization has to be expected whenever different varieties or types of cotton are grown in the same vicinity close enough together for the same bees to visit the flowers of more than one kind.

As the amount of cross-fertilization depends entirely on the number and activity of the bees or other insects that visit the flowers different localities might be expected to differ greatly in the amount of cross-fertilization, and even the same locality in different parts of the season. Thus at the time of our visits to the fields at Yuma and Sacaton there was a notable difference in the activity of the insects at the two places. Several species of large wild bees that were industriously visiting the flowers at Yuma in September were not seen at all at Sacaton.

The fact that cotton flowers readily set seed from their own pollen has led several writers to suppose that cross-fertilization takes place only rarely, but the fact seems to be that foreign pollen is very often brought to the stigmas by the bees before the pollen of the same flower can reach them. This is particularly true of the Egyptian cotton, where the long styles carry the stigmas well up beyond the reach of the short stamens. In Upland varieties which have the stigmas shorter and the stamens longer the opening of the anthers brings the pollen against the stigmas without external assistance, but a long-styled Egyptian flower might remain unfertilized unless visited by insects. The pollen grains of the cotton plant are too large to float about in the wind and also have their surfaces moist and sticky. At the same time they are covered with spines which keep them from adhering too closely to each other and yet help to hold them on the hairs of the bees, as well as on those that cover the stigmas.

The idea that cross-pollination is not frequent has probably been strengthened by the fact that hybrids are easily overlooked in experiments where only Upland varieties are being planted. This is because many of the hybrids have a rather close resemblance to one or the other of the parents or are merely intermediate between them. No such range of diversity appears as when two widely different types of cotton are crossed. Hybrids between the two related Upland varieties are generally much less different from the parents than the diversities that arise in the parent varieties without hybridization. And since the usual effect of hybridizing similar varieties of Upland cotton is to shorten the lint, many such hybrids may be thrown out in the process of selection without their true nature being recognized.

When Upland cotton is hybridized by an Egyptian or Sea Island variety the lint does not deteriorate in the first generation, as compared with the long-stapled parent and the hybrid character of the plant usually becomes obvious at once by reason of its greatly increased stature, which equals or exceeds that of the Egyptian parent. The large size naturally draws attention to the many other features of the Egyptian cotton which are predominant in hybrids with Uplands. This predominance of the Egyptian characters, which makes it so easy to detect Egyptian hybrids in Upland varieties, has the opposite effect of increasing the difficulty of recognizing all the plants of Upland parentage in a field of Egyptian cotton. In the first generation it is still very easy to distinguish them in the great majority of cases. In spite of the general resemblance to the Egyptian parent in stature and habit of growth there are many unmistakable features which enable nearly all of the hybrids to be detected without difficulty; but there are others which only those who have made a special study of the subject can hope to recognize, and some in which the most careful inspection has failed to detect any certain indication of a mixed parentage even when known to exist. If only the first generation of the hybrids had to be feared it is possible that the purity of a variety might be safely guarded, but when hybrids have been diluted for several generations of crossing back upon one of the parental stocks it becomes well-nigh impossible to separate them.

Even the most skillful selection can not eliminate hybrids from a cotton variety unless they are taken out before they begin to blossom. Rejection of the seed of the hybrid plants does not dispose of the other seeds borne by other plants which have been fertilized by the hybrid pollen. And even though the plants raised from these seeds should again be rejected, the process of forming hybrids may still continue. The foreign blood would become more attenuate, of course, with each generation and the hybrids would more and more resemble the pure stock.

Many plants in the Egyptian experiments show such slight and indefinite departures from the Egyptian type that it is often very difficult to settle upon the non-Egyptian characteristics of particular individuals. But when the abundance of these doubtful cases is taken into account it becomes in itself a sufficient evidence of the fact of hybridity, when a planting is considered as a whole. The objection to these dilute or doubtful hybrids is not alone that they are likely to produce a slightly different lint, which lessens the uniformity of the commercial product, but that they are likely in later generations to give rise to distinctly degenerate plants, which will show some obvious hybrid character and a marked deterioration of lint.

DISTINCTIVE CHARACTERS OF HYBRIDS.

The facts already stated regarding hybrids show that it will always be necessary to guard against hybridization and to recognize it at once if it occurs accidentally, in order to prevent its extension in districts where Egyptian cotton is being grown. The farmer who grows Egyptian cotton, as well as the specialist who studies the crop, will need to be informed regarding hybrids. Thus it seems worth while to place on record some of the more salient facts established by our studies of diversity among the hybrids of the Upland and Egyptian types of cotton, in order to show something of the relative importance of the different characters as evidences of hybridization.

STATURE AND METHODS OF BRANCHING OF HYBRIDS.

Many hybrid plants are conspicuous by reason of their more robust stature. Having greater vegetative vigor than the plants of unmixed descent they grow to larger size. Many robust plants are tall, so that they stand out, even at a distance, but in others the large size is attained by putting out more numerous spreading limbs.

The range in the size of hybrid plants is very wide. Small Upland-like plants 2 to 3 feet high are found (Pl. III, fig. 1) beside huge overgrown plants from 5 to 10 feet high (Pl. III, fig. 2).

A similar wide diversity occurs in the shape of the hybrids. Upright, symmetrical plants of the Upland type are found, but the tall, overgrown plants are constructed on an entirely different plan, usually having basal limbs as long as the main axis.

PRIMARY BRANCHES OF HYBRIDS.

Hybrids often diverge from the pure Egyptian habits of growth in showing a more definite tendency to develop primary (axillary) vegetative limbs instead of forming vegetative limbs by modification of the secondary (extra-axillary) branches that would otherwise bear the fruit. The growth of two branches from the same node is more frequent in the hybrids than in pure Egyptian plants.

Many Upland plants put forth the primary limbs after the fruiting secondaries have developed. The usual habit of the Egyptian cotton seems to be to transform the lower secondaries into vegetative limbs, leaving the primaries entirely undeveloped, unless there has been a severe check or injury or the plant assumes more vigorous habits of growth after fruiting branches have already put out from the lower joints of the stem.

STRONG FERTILE BRANCHES OF HYBRIDS.

Upland cotton has relatively stronger and more horizontal fertile branches than the Egyptian. Hybrids often show this feature in a notable degree and then appear very different from the Egyptian plants. (Pl. III.) The latter usually have short and rather weak branches, which become drooping or pendent if they attain any considerable length. The branches of the Upland cottons and the strong-branched hybrids are borne down, of course, when the bolls become heavy, but this does not keep their relatively greater development from being apparent.

The greater tendency of the Upland cotton to put forth fruiting branches from near the base of the main stalk is often shown in the hybrids, even when the Egyptian tendency to develop limbs becomes predominant in the later growth of the plant and causes the lower fruiting branches to appear small and stunted. The unmixed Egyptian plants may also put forth small fertile branches at the base of the main stalk, especially if the plants do not grow too luxuriantly in the early part of the season. These low-fruiting branches often remain small and stunted if the plants change their habit of growth a little later, but some of the hybrids make this change less readily than the Egyptian cottons and thus show a larger development of the fruiting branches near the base of the central axis of the plant.

FOLIAGE OF HYBRID PLANTS.

The hybrid nature of many plants is made apparent by their leaves. Frequently the leaves have a distinct reddish tint, a character of

Upland cottons. This color is often notably lighter than in the unmixed Egyptians. The light-colored plants usually have the leaves of rather thin texture and with broader, shorter lobes, usually borne in a more definitely horizontal position. This is likely to be true also of other hybrids whose leaves offer no other obvious marks of distinction except that they may have longer and more numerous hairs, especially on the lower surface. Hybrids can not be definitely distinguished from pure Egyptian plants by the texture of their leaves. The leaves may be thin and flexible, as in American Uplands, or even more thick and rigid than in pure Egyptian. Often they are of the texture of Egyptians.

The shape of hybrid leaves varies considerably, not only on the different plants but on the same plant, a condition of diversity more or less common to all cottons. The leaves on the main stalk and limbs are larger than those on the fruiting branches. Some leaves are more deeply cleft than others and the margins of some are crenate, which gives them a wavy outline. In some leaves the lobes are rounded, while in others they are acute.[a]

Three-lobed, five-lobed, and seven-lobed leaves occur, those on the main stem usually having the greatest number of lobes. The bases of the three-lobed leaves are generally oblique to the petiole and straight, while those of the five and seven lobed leaves are either rounded, cordate, or overlapping.

Few of the hybrids have either very hairy or entirely glabrous leaves. Many plants have the leaves hairy on the lower surface, but few bear leaves with hairs on their upper surface; occasionally a plant occurs with entirely smooth leaves. On sparsely hairy leaves the hairs are generally stellate, but on those more densely covered the hairs are simple. Marked hairiness on leaves or other parts of the plants is a clear indication of hybridity. It is considered in Egypt that a reddening of the base of the leaf is an indication of hybridization with the Hindi cotton.

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[a] Mr. H. M. Leake, of India, has investigated the leaf forms of hybrids between varieties of Indian cotton by means of what he calls the "leaf-factor," the ratio of length to width in the middle lobe. As a result of over 10,000 measurements he decides that the average ratios for the hybrids are intermediate between those of the parent types in the first generation. The application of this method to the second and later generations would be still more laborious, owing to the greater range of variation in these generations, and could have no practical value in the detection of hybrids, at least in the series studied by us, because many of them repeat the parental peculiarities or even exceed them. See Leake, H. M., Journal and Proceedings of the Asiatic Society of Bengal, January, 1908, p. 14.

VARIED PHYLLOTAXY OF HYBRIDS.

The normal arrangement of the leaves and branches of both Egyptian and Upland cottons is a three-eighths spiral. Each leaf is separated from the leaf directly above it by eight joints of the stem. A spiral connecting the two leaves and passing through the bases of the intervening leaves makes three turns around the stem. Hybrids may show any one of four different spiral arrangements. Plants with a one-third, two-fifths, or five-thirteenths spirals should be taken as hybrids, though many hybrid plants may have the three-eighths arrangement as in the parent types.

This arrangement is characteristic of the main stem and of the vegetative branches. The leaves on the fruiting branches appear to alternate in a one-half arrangement on all plants, due to the twisting of the internodes to bring all the flowers on the upper side of the branch.

SIZE AND TEXTURE OF BRACTS IN HYBRIDS.

There is a great range in the size of the involucral bracts of hybrid plants. They vary from small bracts, which are often red and which approach most closely the Upland type in texture, to the large, green, bullate bracts with the stiff, brittle texture of the Egyptian plants. The enlarged bracts greatly exceed in size the bracts of either parent, corresponding with the overgrown condition of the hybrid on which they occur. Only the small hybrid plants which adhere closely to the Upland type in other characters bear bracts of pure Upland texture. The mature bracts of most hybrids are rather stiff and brittle, though frequently more pliable in the younger stages of growth than young Egyptian bracts. Because of their Egyptian-like texture the mature bracts on drying have a tendency to curl in like Egyptian bracts, and in this condition are hardly distinguishable from the Egyptian type.

CORDATE FORM OF BRACTS OF HYBRIDS.

Some of the most reliable characters for the ready distinction of the hybrids are to be found in the larger size and the broader and more cordate form of the bracts of the involucre. The bases of the bracts are extended downward each side of the flower stalk into broadly rounded lobes, so that the flower stalk appears to be inserted in a deep notch. In the Egyptian cotton the bracts have no such conspicuous broadening at the base and seldom extend much below the line of attachment to the flower stalk. (Pl. V.)

LONG TEETH OF BRACTS OF HYBRIDS.

The marginal teeth of the bracts of hybrids are longer, broader, and more numerous than in unmixed Egyptian and are often hairy, at least along the margins. Conversely, the notches between the teeth are narrow and sharp in the hybrids instead of being broad and rounded as in the Egyptian cotton. Hybrids with well-developed bracts usually have from 12 to 14 teeth, while the normal number of teeth on the bracts of Egyptian ranges from 6 to 10. They are usually uniformly distributed, each tooth standing by itself, though infrequently three of them may be grouped at the apex, as in the Egyptian parent. The veins of the bracts are also more numerous in hybrids, to correspond with the larger number of teeth, and are generally more prominent, especially on the outer surface, while in the pure Egyptian plants the veins are more prominent on the inner surface of the bracts. (Compare bracts shown in Pls. IV and V.)

Though the numbers and forms of the teeth usually afford the best means of distinguishing hybrids they may give little assistance in difficult cases that approach closely to the Egyptian type. Sometimes the Egyptian forms and numbers of the teeth are preserved, the only sign of hybridity being the greater length of the teeth. In rare cases hybrids may even reduce the number of teeth below that of the Egyptian parent instead of increasing it. Thus at Yuma a hybrid plant was found in which some of the bracts had only 3 or 4 teeth, though others had 6 or 8, like the Egyptian parent. And yet in several other respects this plant showed distinctly Upland features. Even the bracts themselves, with the reduced numbers of teeth, were hairy on the outside, as in the Upland cotton.

REDDENING OF BRACTS OF HYBRIDS.

The outer surfaces of the bracts of many hybrids have a dull pinkish or reddish color, especially those exposed to the sun. This reddening often appears when the bracts are quite young. Sometimes it deepens with age, but on other plants only the young bracts show the reddish tinge. The tendency comes from the Upland cottons, where it is often very pronounced, while among the Egyptian cottons there is seldom any definite trace of it, though an occasional bract may appear somewhat reddish. Thus it may be said that any obvious reddening of the bracts gives reason for suspecting hybridity, and that any decided tendency to the red color is a fairly sure indication and likely to be accompanied by other obvious Upland features.

ABNORMAL FORMS OF BRACTS IN HYBRIDS.

Abnormalities in the form of the bracts are not infrequent in hybrids and are to be considered as one of the evidences of hybridity, especially when many abnormal bracts occur on the same plant. These abnormalities take many forms, but they all appear to represent intermediate stages between normal leaves and normal bracts. It often happens that the leaf at the base of the flower stalk takes on more or less the character of a bract. The slightest and most frequent indication of the change is seen when one of the stipules is enlarged. Sometimes both stipules are enlarged, and one or both of them may be joined to the reduced and shortened blade of the leaf, the petiole being more or less completely suppressed. Finally, bracts which are quite normal in other respects may have one or both of the lateral divisions, which represent the stipules, separated to the base, or the bracts may be in irregular positions or may be abnormal in number.

Involucres composed of only two bracts occur on some of the hybrids, but are not as frequent as in the pure Egyptian stocks raised from newly imported seed. Two-bracted involucres may or may not be accompanied by two-locked bolls. The four-bracted involucres which occur occasionally in Upland cottons have not been observed in the hybrids.

Next to the lint itself, the involucre probably represents the most highly specialized structure of the cotton plant. It is therefore not surprising that hybrids should show these irregularities in the forms of the bracts. Indeed, it seems rather remarkable that such irregularities do not appear in a larger proportion of the hybrids, in comparison with the parent stock. The plants grown from the seed obtained from Mr. Dale showed more frequent and striking examples of abnormality in the bracts than any of the hybrid stocks.

DISTINCT CALYX LOBES OF HYBRIDS.

In many hybrids the calyx, instead of having the nearly straight, even rim of the Egyptian parent, is definitely lobed, as in the Upland cotton. (Pl. V.) Sometimes the lobes are even sharper than in some of our Upland varieties. As in the Upland cotton the largest lobes are those that bear nectaries, those that stand opposite the openings between the bracts. A lobed calyx affords only corroborative evidence of hybridization, since it seems always to occur in connection with other more apparent hybrid characters, such as the broad, long-laciniate bracts. With white, bell-shaped flowers of the Upland type the calyx is constantly lobed, and these also have a prominent hairy rim above the internal nectary of the calyx, as in Upland cottons. The absence of lobes can not be accepted as evidence of pure blood, for plants with other distinctive features of hybrids may have no lobes on the calyx or only the very broadly rounded, scarcely appreciable scallops frequent among pure Egyptian cottons.

A stronger development of the ring of hairs above the internal nectary of the calyx is also to be considered as an indication of Upland ancestry. This character seems to be especially prepotent in hybrids with Kekchi cotton.

LIGHT-COLORED FLOWERS OF HYBRIDS.

Many of the hybrid flowers share the pale, creamy white color of the Upland parent. This renders pale-flowered hybrids very conspicuous among yellow-flowered Egyptian plants and affords a ready means of separation. But, unfortunately, not all of the hybrids have the creamy flowers. In some of the hybrid plants the flowers are of a pale yellow, while others have them as dark as any of the Egyptian cottons.

PALE SPOTS ON THE PETALS OF HYBRIDS.

Many of the hybrids lack the dark reddish purple spot found at the base of each of the petals of Egyptian cottons, others have faint or broken spots, while still others have the spots as dark as in any of the Egyptians. The variations of the spot seem to be quite independent of those of the color of the petals. Though spots are most frequently absent in the light, creamy flowers, the pale flowers may also have very dark spots, or the deep yellow flowers may have faint spots, or none at all. If, in addition to this variability among hybrids, we consider the fact that pale petals and faint spots sometimes appear among the newly imported Egyptians, it becomes apparent that these color characters alone are not to be relied upon for distinguishing hybrids, except as they add to the evidence afforded by other features.

LARGE PETALS OF HYBRIDS.

Measurements show that the petals of hybrids are not only much larger than those of Upland cottons, but are generally larger than those of pure Egyptian plants. At Sacaton the petals of hybrids ranged from $2\frac{1}{4}$ to $3\frac{1}{2}$ inches long by $1\frac{3}{4}$ to $2\frac{3}{8}$ inches broad, while those of the pure Egyptian petals averaged distinctly smaller, ranging from 2 to $2\frac{7}{8}$ inches long by $1\frac{1}{2}$ to 2 inches broad. At Yuma the petals averaged smaller both in the hybrids and in the pure Egyptian flowers and the differences between the two were less. Though the hybrid flowers are usually larger than the Egyptian, large flowers are not a positive indication that the plant is a hybrid. Some hybrids have flowers which are smaller than many of the Egyptian flowers.

CUP-SHAPED FLOWERS OF HYBRIDS.

Hybrids with pale petals also share the Upland shape of the flower. The petals spread more widely apart near the base and give the flower a more open, cuplike shape, obviously different from the more cylindrical or tubular form of the Egyptian flowers, which never open so widely as those of the Upland cotton. This wider opening of the pale flowers increases the resemblance to the Upland parent, while hybrids with flowers of a deep yellow color usually have the complete Egyptian form as well. (Pl. VI.)

DARKENING OF OLD FLOWERS OF HYBRIDS.

The flowers of the Upland hybrids, though usually paler when fresh than the Egyptian flowers, turn darker with age, first becoming pink and then deepening into dull purple as the corolla shrivels and dries, whereas the old flowers of the Egyptian cotton usually remain yellow or darken only a little. This difference was very noticeable at Yuma, where Mr. Kearney had made use of it for distinguishing the hybrids, but at Sacaton it was found to be much less reliable, for many apparently pure Egyptian plants were found in which the old flowers had turned to a dull purple or were blotched and spotted with purple to nearly the same extent as in Upland varieties and hybrids at Yuma.

LONGER STAMENS OF HYBRIDS.

Many hybrids, and especially those with pale flowers, have the filaments or stalks of the stamens like those of the Upland cotton, much longer than in the pure Egyptian. (Pl. V.) These longer filaments require more room than the narrow tube of the Egyptian flower affords. This fact may help to explain the apparent correlation between the light color and more open Upland shape of the flowers. As the light flowers almost always have long stamens the more open shape may follow as a mere mechanical necessity.

Hybrids that have long stamens like the Upland parent do not show very plainly the regular Egyptian arrangement of the stamens in five double longitudinal rows. Other hybrids have the numbers of the stamens greatly reduced, and in these the rows may be very apparent. More or less complete abortions of the stamens are rather frequent in hybrids. The anthers may fail to develop to the full size or may appear to be fully formed and yet fail to open. With the long filaments of the Upland parent anthers of the smaller Upland type are usually associated.

PALE POLLEN OF HYBRIDS.

Pollen grains of very irregular sizes are often found in the anthers of hybrids, and sometimes there appears to be a distinct diversity of color, though this is not easy to determine, because the apparent color of the grains differs so much in different lights, even when the color is really uniform. Pale-flowered plants usually have the pollen also of a pale creamy or yellowish shade, while the pollen of yellow-flowered plants often shows the deep orange of the Egyptian parent.

THICKENED STYLES OF HYBRID FLOWERS.

The style is uniformly thicker in white-flowered hybrids; nearly as thick as in the Upland type. In some hybrids the styles are as short as in the Upland cottons, while in others they are intermediate in length between the Upland and the Egyptian. They are seldom as long as in pure Egyptian. (Pl. VI.)

PEA-GREEN BOLLS OF HYBRIDS.

Many hybrids can be distinguished at once by the light pea-green color which renders the bolls obviously different from the dark-green bolls of the Egyptian. The lighter shade of green is largely due to the fact that the oil glands are fewer in number or more deeply sunken and covered with green tissue, as in Upland cotton, instead of being exposed on the surface as in the Egyptian. (Pl. V.)

Bolls that have the light color almost always show something of the large size and more broadly pyramidal shape of the bolls of Upland cotton and thus appear the more distinct from the narrower and more cylindrical bolls of the Egyptian. Nevertheless, there appears to be a complete series of gradations in sizes, colors, and shapes. Plants shown by other characters to be hybrids may bear bolls which by themselves would appear genuinely and typically Egyptian. As already noted in the discussion of the Egyptian varieties, they show a much greater amount of diversity in boll characters than would be expected in any well-bred Upland variety. This adds, of course, to the difficulty of using boll characters as a means of distinguishing hybrids, except in the cases where the lighter color and different texture of the surface are obvious.

FIVE-LOCKED BOLLS OF HYBRIDS.

The bolls of hybrid plants are able to show the complete range of diversity of the parent types. Many hybrids have 2 to 4 locks, like the Egyptian parent, while others have 3 to 5 locks, like the Upland parent. Five-locked bolls are so rare a phenomenon in Egyptian cotton that they are always to be considered as an indication of hybridity. Nevertheless, it has not been necessary to reckon any plant as a hybrid because of this character alone, for it seems never to appear in a hybrid except in connection with other obvious Upland features. Five-locked bolls seldom appear singly; where one is found, several others are to be expected if the plant is at all productive.

Sometimes the number of five-locked bolls nearly equals that of the four-locked, but such cases are not common. Plants with numerous five-locked bolls are likely to have very few with three locks or none at all. When there are no five-locked bolls an absence of three-locked bolls or any notable preponderance of the four-locked bolls over the three-locked may serve to call attention to a hybrid. There is said to be a popular impression in Egypt that even four-locked bolls are found only on hybrids. This may be true in districts where the plants attain only small size.

The representation of five-locked bolls among the Egyptian hybrids in Arizona appeared to be distinctly less than in the hybrids between Kekchi cotton and Egyptian, which had been studied previously in Texas. Some of the long-staple Upland varieties have very few five-locked bolls, but there had also been opportunities of crossing with big-bolled varieties, where five-locked bolls are usually more numerous than in the Kekchi. It is possible that the five-locked tendency is more effectively inherited from the Kekchi cotton or that the difference represents an influence of the external conditions, which have been found to have definite effects upon the number of locks.

TWO-LOCKED BOLLS OF HYBRIDS.

Hybrids often exceed the pure Egyptian plants in the proportion of two-locked bolls. At Sacaton the bolls of pure Egyptian plants were quite consistently three-locked, the proportion of two-locked bolls being notably less than on many plants which were obviously hybrids. It seemed at Sacaton that any large number of two-locked bolls was as good an indication of the hybrid nature of a plant as a similar abundance of four-locked bolls. An average of 4.6 per cent of two-locked bolls was found on seven pure Egyptian plants. The highest percentage for any one plant was 12, and this plant also had the greatest number of two-locked bolls. Some of the hybrids are as consistently three-locked as any of the pure Egyptian plants.

At Yuma Messrs. Kearney and Peterson had formed an impression that the number of two-locked bolls was greater in 1908 than in previous seasons, which would accord with other indications of less favorable conditions for the cotton. Seven of ten plants of acclimatized Mit Afifi at Yuma were found to have two-locked bolls in the average proportion of about 5 per cent, nearly the same as at Sacaton. Of ten plants taken at random in a plot grown from imported Mit Afifi seed nine had two-locked bolls—in the general proportion of 13.4 per cent. Similarly striking reductions in the numbers of locks of the bolls have been found to take place in Central American varieties when first introduced into Texas.

FUZZY SEEDS OF HYBRIDS.

A majority of hybrid plants have their seeds covered with long dense fuzz. The color of the fuzz varies from green through the different shades of brown to white. A large proportion of the hybrids can be distinguished by the long dense fuzz, but this is by no means a safe guide in all cases. Very fuzzy seeds were found, as already described, in the newly imported Egyptian cotton, and on the other hand many hybrids have seeds more completely naked than the seeds of the pure Egyptian. Indeed, Mr. Kearney has noted among some of his special selections that the smooth seeds of hybrids fall into a rather distinct class. There appear to be very few hybrids with the same amount of fuzz that is usual in the Egyptian cotton. Those that have less fuzz than the Egyptian usually have much less or none at all.

A plot grown by Mr. E. W. Hudson at Sacaton, Ariz., from carefully selected smooth seeds contained nearly as large a proportion of obviously hybrid plants as a row that had been planted from a selection of the fuzziest seeds. Many plants grown from the fuzzy seeds showed no definite indications of hybridity, and the seeds of these plants in many cases bore as little fuzz or less than those of pure Egyptian plants. Plants were also found in other fields that had densely fuzzy seeds, but no other hybrid characters. The full range of diversity in seeds of hybrids is from perfectly smooth to densely fuzzy, fully covering the range of diversity for both the parent types and extending beyond.

Plants that appear distinctly degenerate in the strength of the fiber or in the number of seeds in the lock often have seeds that are completely devoid of fuzz. On the other hand, many of the very smooth-seeded hybrids at Yuma had fiber that was excellent in strength and in all other characters, comparing very favorably on the average with the lint from the fuzzy-seeded hybrids.

SIZE OF HYBRID SEEDS.

The seeds of hybrids range in size from that of Egyptian to an accentuated size larger than that found in Upland cottons. Hybrid seeds which come within the range of diversity for fuzziness in the seeds of newly imported stock may exceed the imported seeds in weight by 1 or 2 grams to the hundred. The majority of fuzzy seeds are of the size of Upland seeds, but some are of enormous size, nearly twice as large as those of Upland. In Kekchi × Egyptian hybrids the seeds are very large and have green fuzz in the first generation, these features tending to disappear in the second and third generations.[a]

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[a] Cook, O. F. "Reappearance of a Primitive Character in Cotton Hybrids," Circular 18, Bureau of Plant Industry, U. S. Department of Agriculture. 1908.

It seems to be a general rule that fuzzy seeds attain a larger size than those that have less fuzz. The largest of the fuzzy seeds were selected from six different lots and found to average larger than the largest of the seeds that remained.

Weights of fuzzy and normal seeds.

[Stated in grams per 100 seeds.]

Weight of selected fuzzy seeds.	Weight of largest of remaining seeds not unusually fuzzy.	Weight of selected fuzzy seeds.	Weight of largest of remaining seeds not unusually fuzzy.
Grams.	*Grams.*	*Grams.*	*Grams.*
17.06	14.46	17.55	14.11
16.91	14.78	17.67	13.93
17.96	14.48	15.93	15.30

In five of the six cases there was a notable difference in favor of the fuzzy seeds. It is perhaps worthy of note that the figures showing the smallest inequality were derived from a plot which consisted largely of hybrids. Here the fuzzy seeds were smaller and the non-fuzzy larger than elsewhere.

SUPERIOR LINT OF HYBRIDS.

One of the notable peculiarities of the hybrids lies in the fact that the lint of the first generation hybrids is often superior to that of the pure Egyptian plants. The proportion of first generation hybrid plants having very long, fine, strong lint is also notably higher than among the pure Egyptian plants. At the same time hybrids are frequently to be found which are as bad or worse than the poorest of the Egyptians, with very short, very sparse, or very weak "perished" lint.

The superiority of the good hybrids is so striking as to lead all observers to raise at once the question of establishing a hybrid stock as a substitute for the pure Egyptian. At the same time it has to be admitted that there is nothing to warrant the hope of practical success in this direction. The diversity among the hybrids is too great and experiments have not yet shown that uniformity can be secured, even by many generations of selective breeding.

Nevertheless, another possibility of utilizing hybrids in the production of cotton of very high grade remains to be considered. Experiments with crosses between Egyptian cottons and Central American varieties belonging to the Upland series have shown that the lint of first generations of hybrids is superior to that of the subsequent generations and very much more uniformly good in the individual plants. These facts suggest that a culture based on first generation hybrids might have better prospects of practical success than the attempt to develop hybrid stocks. With a type of cotton so different from the Egyptian as the Kekchi, it would not be difficult to produce first generation hybrids on a commercial scale. The small size of the Kekchi plants and their broad-lobed hairy leaves would enable them to be separated very readily from the more robust and smoother hybrid plants, so that only hybrids need be allowed to grow to maturity.

The quality and uniformity of the crop might be still further guarded, if necessary, by selection in the field, for the larger size and greater fertility of the hybrid plants would make field selection very easy and expeditious. Indeed, such field selection of lint would involve much less difficulty than the careful selection of seed plants required to maintain the superiority of any carefully tried variety of cotton like the Sea Island or Egyptian.

The most serious objection to the staple furnished by the hybrids is that it usually lacks the brownish tinge, which is one of the commercial characteristics of most of the grades of Egyptian cotton that are imported into the United States. If this feature is important enough to make a difference in the price it may be possible to obtain darker hybrid lint by using a brown strain of the Kekchi cotton as the female parent of the hybrids.

Observations made by Mr. Kearney upon hybrids between the Egyptian cotton and several varieties of the Upland series appear to indicate that such crosses have less uniformity in the seed characters in the first generation than has been obtained in our experiments with the Kekchi cotton. Thus, of 280 Egyptian-Upland hybrids recorded at Yuma 124 had smooth seeds, while 156 had fuzzy seeds. No such proportion of smooth seed has been noted in the Kekchi-Egyptian hybrids, where smooth seeds are very rare in the first generation.

It has been noted already that smooth-seeded hybrids often have weak lint, whereas fuzzy-seeded hybrids, like those formed with the Kekchi cotton, generally have strong lint. Even when the lint becomes short or sparse it usually remains very strong. Fuzzy-seeded hybrids with weak lint were not noticed in the field at Sacaton, but Mr. Kearney's records show a case of this kind from Yuma. The character of the very fuzzy seeds of the Kekchi cotton seems to be much more strongly prepotent in hybrids with the Egyptian cotton than the corresponding character of the Upland varieties, though the presence of smooth seeds in some of our Upland types may help to explain this apparent difference.

PRINCIPAL CHARACTERS FOR DISTINGUISHING HYBRIDS.

For practical purposes it is possible to give a list of several characters which are sufficiently definite to serve as guides in eliminating hybrids. Any one of these characters affords a sufficient ground for rejecting a plant as a hybrid, but in addition to the plants which may be recognized by these characters it will be good policy, in the interest of maintaining a pure stock, to reject any individual that shows a notable difference from its neighbors either in habits of growth or in any definite detail of form or color of foliage, flowers, bolls, seeds, or lint.

Breeders may have more difficulty than practical farmers in discarding hybrids. The farmer who is interested only in keeping his stock pure can at once rogue out any unusual plant, while the breeder will need to be very careful to avoid the danger of discarding a valuable sport on a mere suspicion that it may be a hybrid.

Following is a list of the most obvious and reliable characters for distinguishing hybrids:

(1) Cordate, hairy, involucral bracts, with numerous (12 to 14) teeth.
(2) Large, cup-shaped, white flowers, with pale petal spots or no spots at all.
(3) Large pea-green bolls.
(4) Bolls with five locks or a large percentage of bolls with four locks (25 per cent or upward).
(5) Densely fuzzy, large seeds.
(6) Hairy leaves, leaf stems, or branches.
(7) Calyx with triangular pointed lobes.

CORRELATIONS OF CHARACTERS IN HYBRIDS.

An effort was made to detect correlations of characters in the hybrids as a further means of deciding the question of hybridity in doubtful cases. If in all plants known to be hybrids or definitely recognizable as such a character were always found to be combined with some other character, there would be less reason to believe that a plant was a hybrid when only one of these characters appeared. Such correlations might assist in determining whether any particular plant represented a first generation hybrid or a later generation, for the study of other cotton hybrids has shown that fairly definite correlations may appear in the first generations which are broken up in later generations.[a]

In first generation hybrids between Egyptian cotton and the Kekchi cotton of Guatemala the seeds are almost always larger than those of either parent and these larger seeds are always covered with very dense bright-green fuzz. In later generations this grouping of characters is broken up. The seeds return to normal size and the green fuzz tends to disappear, giving place to the white fuzz of the

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[a] That external conditions may also have a notable influence upon the expression of characters in hybrids has been shown in a previous report, "Suppressed and Intensified Characters in Cotton Hybrids," Bulletin 147, Bureau of Plant Industry, U. S. Department of Agriculture. 1909.

Kekchi parent or to the naked black seed of the Egyptian parent. Whether because the Egyptian is the female parent in the present hybrids or because the fuzzy character of the Upland cotton is less prepotent than that of the Kekchi cotton the coordination of seed characters appears not to be so definite.

Nevertheless, it appears to be possible to group a large proportion of the hybrids into a few series characterized by fairly definite complexes of characters. All that can be claimed for the present is a probability that the different combinations of characters stand in fairly definite relations to fertility and lint production. As a basis for further study of the subject, brief descriptions of a few of the principal types have been drawn.

SYNOPSIS OF PRINCIPAL TYPES OF HYBRIDS.

The following are the principal types of hybrids:

(1) Limbs stiff, erect, very upright, with short internodes; bolls small and lint inferior.

(2) Limbs upright, somewhat spreading, with long internodes; bolls large, 3-locked, 4-locked, and sometimes 5-locked; lint abundant and usually long.

(3) Limbs spreading, main axis generally strong and erect; bracts broadly cordate; flowers pale; bolls of Egyptian type; lint usually buff and like Egyptian in quality.

(4) Plants lower and more spreading or prostrate, with long internodes; bolls numerous, 4-locked and 5-locked; lint long; seed well linted.

(5) Plants of Upland habit of growth; bolls mostly 4-locked and 5-locked; seed usually large and fuzzy; lint abundant, but short.

TYPE I OF HYBRIDS.

The plants of Type I are tall and strictly upright. The basal limbs equal or exceed the main stem in length, are stiffly erect, and make a compact growth. The leaves are generally large, not deeply lobed, and often wrinkled or bullate. The fruiting branches are slender, short, and infertile, and usually bear only one or two small bolls with only a few seeds. The lint is short and very sparse, and covers only a small area at the upper end of the seed. The bracts are broad, deeply cordate, with rather short but narrow laciniæ. The flowers are pale, with faint petal spots or none at all. These might be called "degenerate hybrids."

TYPE II OF HYBRIDS.

Type II is distinguished by excessive vegetative growth, long internodes, large five-lobed leaves, long ascending fruiting branches, and broad, cordate bracts of the Upland type. The plants may be either very productive or nearly sterile. The bolls are long and pointed like Egyptian, but are mostly four-locked and much larger than Egyptian, and differ further in their pale pea-green color. The seeds are large and well covered with rather long lint, which is usually longer and less abundant on smooth than on fuzzy seeds. The flowers are larger than in Egyptian, petals pale yellow, and their basal spots faint. The filaments of the stamens are long, as in Upland, and the stigma is often shortened, protruding only slightly beyond the long stamens. The calyx is shorter than Egyptian and sharply lobed like Upland cotton.

Three forms of plants might be distinguished in this type, differing in the development of the basal branches as compared with the main axis:

(1) The first class has short, weak, spreading, basal limbs, but a very strong, upright, main axis. Sometimes late in the season primary limbs develop from the main axis near the top of the plant and bear branches.

(2) The second class differs from the first only in having two or three longer, more upright basal limbs. These first two types have strongly developed fruiting branches and are very productive.

(3) The third type has several very strong limbs, as long as the main axis. The fruiting branches are weak and bear few bolls.

TYPE III OF HYBRIDS.

Of the five types of hybrids Type III is the most like Egyptian. The plants are Egyptian in form, having the strong, slightly spreading basal limbs as long as the main axis. The bolls are three-locked and dark green. The lint is buff. The hybrid plant is distinguished from the Egyptian mainly by its larger size, broad, cordate bracts, and rather pale flowers. The bolls are enlarged and the seeds are large and generally fuzzy. Such plants are usually infertile.

TYPE IV OF HYBRIDS.

Type IV includes the most productive and the most abundantly linted plants in the hybrid series. The plants are more spreading than the Egyptians, having a strong main axis with long, widely spreading or prostrate basal limbs. The fruiting branches are horizontal. All internodes are long. The leaves are rather large, five-lobed, and generally hairy on the lower surface. Other distinguishing features are broad, cordate bracts, faint petal spots, a predominance of large, four-locked and five-locked bolls, and large seeds. The lint is abundant and fine; smooth seeds bear a longer staple than fuzzy seeds. Most of the plants have red stems, but a few green-stalked plants occur. Some of the plants are more upright or more compact than others, but apart from these slight differences there is a very consistent agreement in characters, often extending to minute particulars.

TYPE V OF HYBRIDS.

The fifth type includes the small Upland-like plants which can be easily detected as hybrids by their small size and hairy Upland-like leaves. Only the main axis and the fruiting branches are developed to any extent, the basal limbs being suppressed or remaining short and spreading. The bolls are large, four-locked and five-locked, light green, and with shallow gland pits. The seeds are large and usually fuzzy, with abundant, rather short, but often fine lint. The flowers are as light as Upland, with either faint or dark spots, very large anthers, cream-colored or whitish pollen, and stigmas protruding only slightly, if at all, beyond the stamens.

CONCLUSIONS.

The general practical conclusions regarding the nature and causes of diversity have already been stated in the introduction as the best means of indicating to the reader in advance the point of view from which our studies were made.[a] The following paragraphs constitute a somewhat more detailed summary of the facts that have been established, with indications of their bearings upon the problems to be solved and methods to be used in this and other similar investigations.

The Egyptian and Upland cottons belong to the same general series of American types and are capable of showing similarly wide ranges of diversity, especially when grown under new and unwonted conditions. This community of origin and parallel behavior warrants a tentative application to the Egyptian cotton of facts and principles learned in the study of the acclimatization of tropical American cottons in the United States.

Studies of Egyptian varieties grown at Yuma from imported seed show many forms of diversity that would not be expected to appear in carefully selected varieties and would usually be ascribed to hybridization. In the plantings of Arizona-grown Egyptian seed this diversity appears to have increased rather than to have diminished, even after the exclusion of all individuals that can be distinguished as hybrids.

The difficulty of acclimatizing Egyptian cotton is increased by the fact that the varieties have been distinguished thus far by lint characters alone, with little or no reference to the vegetative features. Selection for long lint has not reduced the diversity of forms, and the crossing of these varied forms with each other tends to prolong the condition of diversity instead of hastening the completion of acclimatization.

---

[a] The practical aspects of the experiments with Egyptian cotton in the season of 1908 have been treated by Messrs. Kearney and Peterson in Circular No. 29 of the Bureau of Plant Industry, published April 16, 1909.

To secure prompt acclimatization, selection should have reference to the normal behavior of the plants rather than to new characters or to special excellence in particular characters. Acclimatization is to be distinguished both in aims and in methods from the selective breeding by which new and improved varieties are obtained.

Incomplete acclimatization renders the plants unusually susceptible to differences of external conditions. Different parts of the same field often show serious differences in the fertility of the plants, as well as in the length, strength, and abundance of the lint. These discrepancies appear out of proportion to the differences in the conditions as shown by the size and vegetative vigor of the plants, but can be understood if we remember that fertility and early bearing depend upon the habits of branching which the individual plants may adopt and that such habits are readily influenced by external conditions.

Additional diversity is occasioned by the appearance in the Egyptian fields of numerous hybrids between the Egyptian cotton and the Upland. The presence of so many hybrids is explained by the fact that the cotton flowers at Yuma are visited by insects which are apparently more numerous and active than at any other points where cotton experiments have been described, either in the United States or in foreign countries. Such insects will render it practically impossible to maintain pure stocks of Egyptian seed if Upland cotton is grown in the same localities.

Hybrid plants, at least in the first generation, are usually more fertile than the pure Egyptian plants and produce longer and stronger lint. In spite of the diversity of vegetative characters among the hybrids their lint is commonly more uniform in length and strength than that of the pure Egyptian plants, though distinctly different from the pure Egyptian fiber. In later generations of hybrids degenerate plants occur, infertile and inferior in lint.

The very high grades of lint that may be obtained from first generation hybrids and their extreme vigor and productiveness warrant the consideration of means for obtaining hybrid seed in commercial quantities. A possibility of producing fields of hybrid plants lies in the fact that certain of the characters of Egyptian cotton are strongly prepotent, especially in the first generation. Thus, if the Egyptian were crossed on the small Kekchi type of Upland cotton the young hybrid plants could readily be distinguished from the Kekchi plants and the latter removed in the process of thinning the seedlings. To recognize the young hybrids among Egyptian seedlings would be much more difficult, if not actually impossible.

This possibility of utilizing hybrids should not be allowed to obscure the fact that hybrids are a distinct disadvantage in fields of Egyptian cotton because they interfere with the uniformity of the lint. The elimination of hybrids is rendered very difficult by the fact that many of them show no perceptible differences in their vegetative characters and habits of growth to distinguish them from the pure Egyptian plants before the involucres and floral buds have developed. Nevertheless, it is necessary that the hybrids be eliminated as soon as they begin to flower; otherwise their pollen will infect the next generation. To reject the seed of hybrid plants does not completely purify an Egyptian stock that has once been hybridized.

The preceding considerations make it evident that Upland cotton must either be excluded from regions when Egyptian cotton is to be grown, or local sources of supply of pure, acclimatized Egyptian seed must be established and very carefully guarded from contact with Upland cotton if commercial cultures of Egyptian cotton are to be permanently maintained in Arizona and the neighboring States. Even if a culture based on hybrids should prove feasible it would still be essential to maintain pure stocks of the parent types to continue the production of the hybrid seed.

The diversity in the behavior of Egyptian cotton at the different places where it was grown this year shows that it may not suffice to complete the process of acclimatization in any one locality if this seed is to be planted afterwards in any other localities. It should not be supposed that the possibilities of growing Egyptian cotton in a new locality can be judged from a single planting. Even after acclimatization has been completed and the industry established, it will still be necessary to take into account the need of adjustment to local conditions whenever the crop is to be extended to a different district.

PLATES.

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DESCRIPTION OF PLATES.

The illustrations used for these plates were furnished by Mr. Kearney. The photographs were taken at Yuma, Ariz., at the end of the season (October 7–13, 1908), when the plants were fully mature.

PLATE I. Fig. 1.—Egyptian cotton. An acclimatized plant showing the form taken when a strong central stalk is developed. Vegetative branches rather small; fruiting branches large. Fig. 2.—Egyptian cotton. A plant from newly imported seed showing the form taken when there is a strong development of the vegetative branches. Fruiting branches small and unproductive; no fruit on lower half of plant.

PLATE II. Fig. 1.—Egyptian cotton. A plant showing an intermediate development of branches, the central stalk and vegetative branches both bearing numerous fertile branches. Fig. 2.—Egyptian cotton. A large and very fruitful plant bearing more than 300 bolls. Branches equal to main stem, but likely to be bent or broken to the ground by the weight of the fruit.

PLATE III. Fig. 1.—Egyptian-Upland cotton hybrid. A small plant with the habit of growth of Upland cotton. Bolls pea-green in color, borne mostly near the bottom of the plant, smaller than usual in hybrids; lint very abundant. This plant represents the fifth type of hybrids. Fig. 2.—Egyptian-Upland hybrid. A tall, vigorous, fertile plant, showing long fruiting branches and greater fertility at the base of the plant; also showing Upland features of pea-green bolls and green fuzzy seeds. This plant represents the second type of hybrids.

PLATE IV. Egyptian cotton, Mit Afifi variety, grown from newly imported seed. Bracts and bolls from several different plants to show range of difference in shape and markings. The bracts show the typical Egyptian form with the three middle teeth somewhat abruptly prominent. The calyx of the boll with the bracts is split and is not to be confused with the lobes of the calyx of the hybrid shown in the next plate. (Natural size.)

PLATE V. Mature unopened bolls of first generation hybrid of Egyptian and Upland cottons at Yuma. The larger size, more pyramidal shape, smaller and more shallow pits, and pea-green color afford ready distinctions. (Natural size.)

PLATE VI. Fig. 1.—Flower from an Egyptian plant and a flower from a hybrid plant, showing a broader and more cup-shaped, shorter corolla. Fig. 2.—Staminal columns of Egyptian flowers, with short filaments and long styles. Fig. 3.—Staminal columns of hybrid flowers, showing the longer filaments and shorter, thicker styles characteristic of the hybrids. (Natural size.)

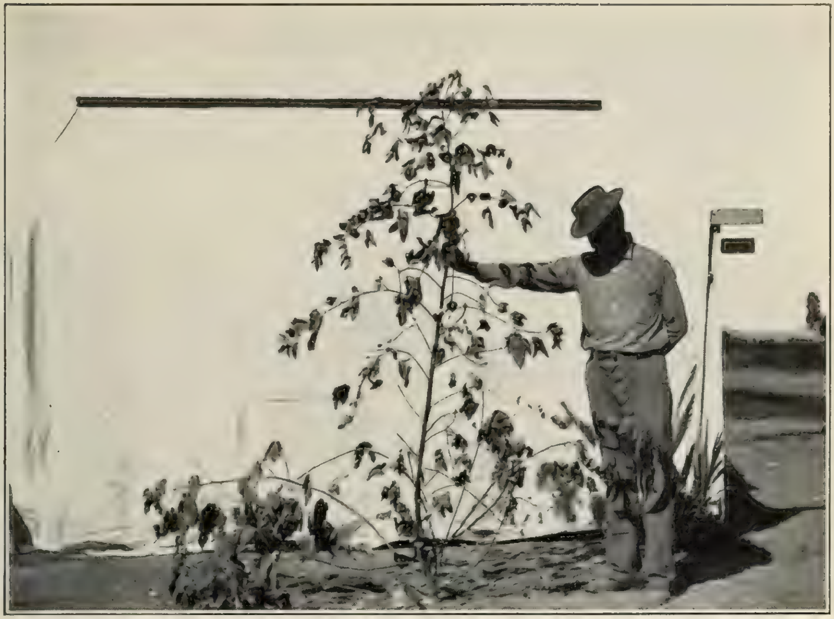


FIG. 1.—FERTILE PLANT OF EGYPTIAN COTTON, SHOWING STRONG CENTRAL STALK AND LONG FRUITING BRANCHES.

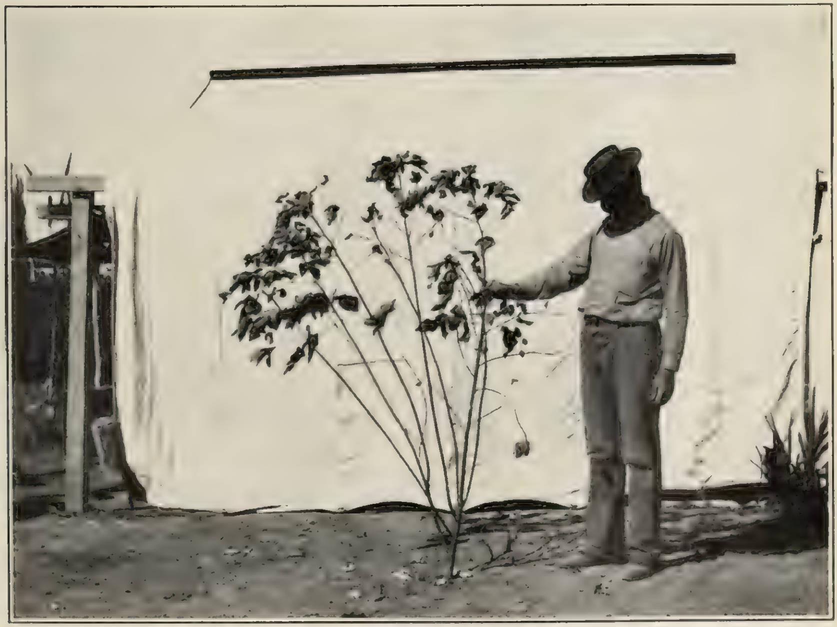


FIG. 2.—PLANT OF UNPRODUCTIVE TYPE OF EGYPTIAN COTTON, SHOWING NUMEROUS VEGETATIVE BRANCHES AND VERY SMALL FRUITING BRANCHES.

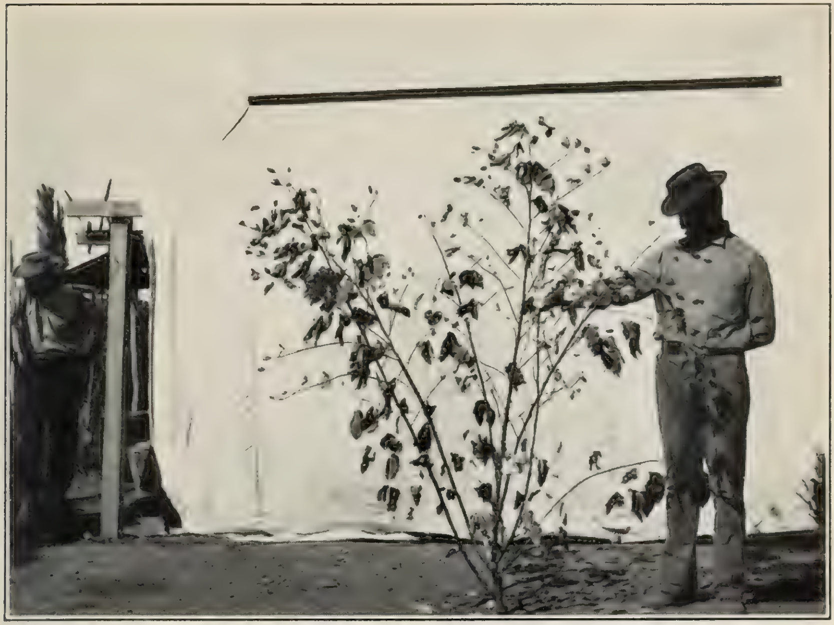


FIG. 1.—MODERATELY PRODUCTIVE PLANT OF EGYPTIAN COTTON, WITH BOTH VEGETATIVE AND FRUITING BRANCHES WELL DEVELOPED.

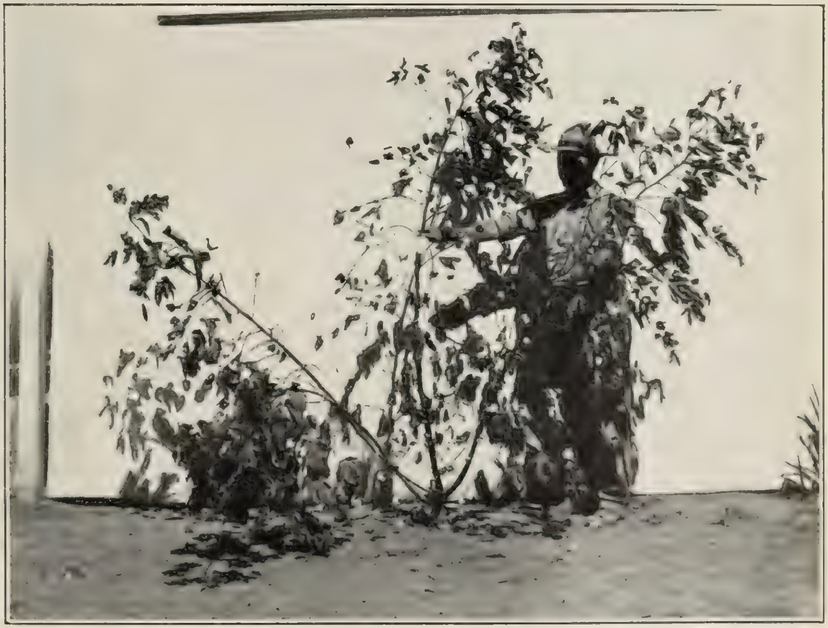


FIG. 2.—VERY PRODUCTIVE EGYPTIAN COTTON PLANT, WITH ABUNDANT FRUITING BRANCHES.

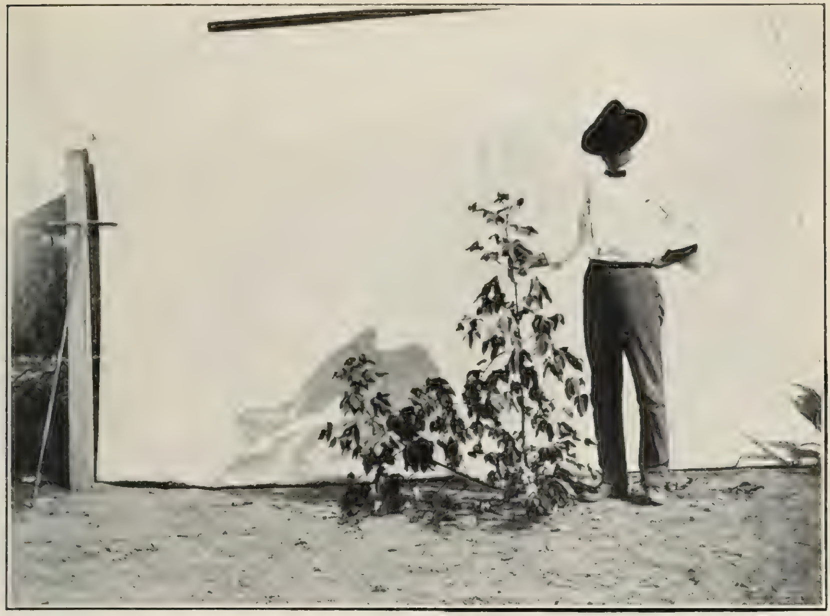


FIG. 1.—EGYPTIAN-UPLAND HYBRID. A SMALL PLANT OF THE UPLAND TYPE.

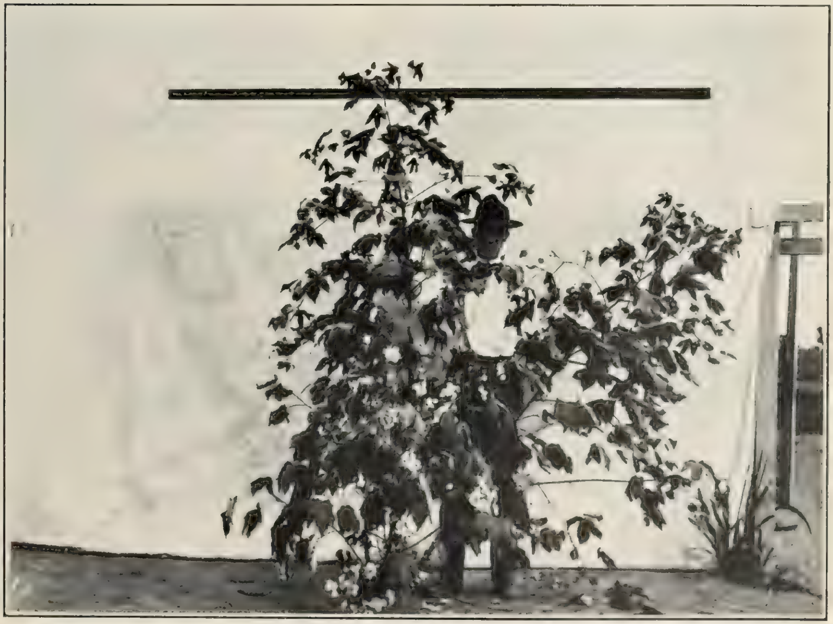
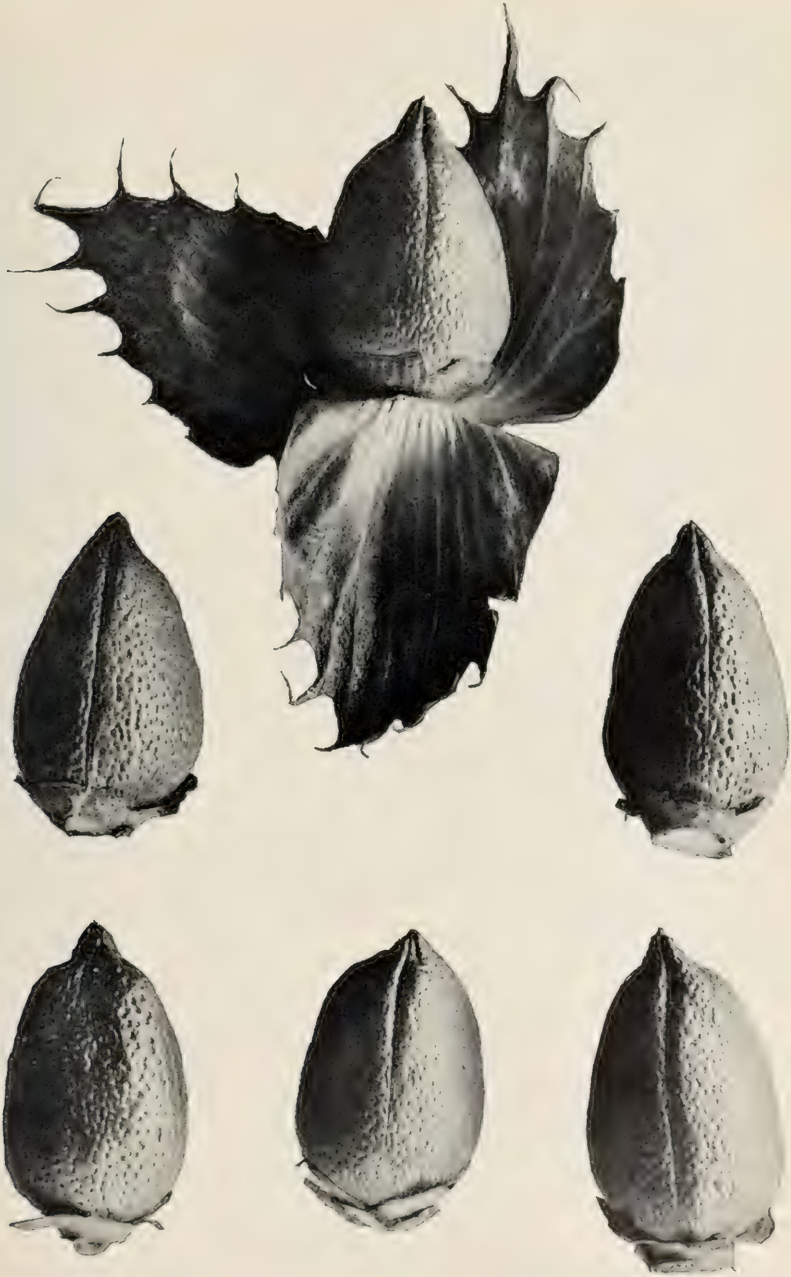
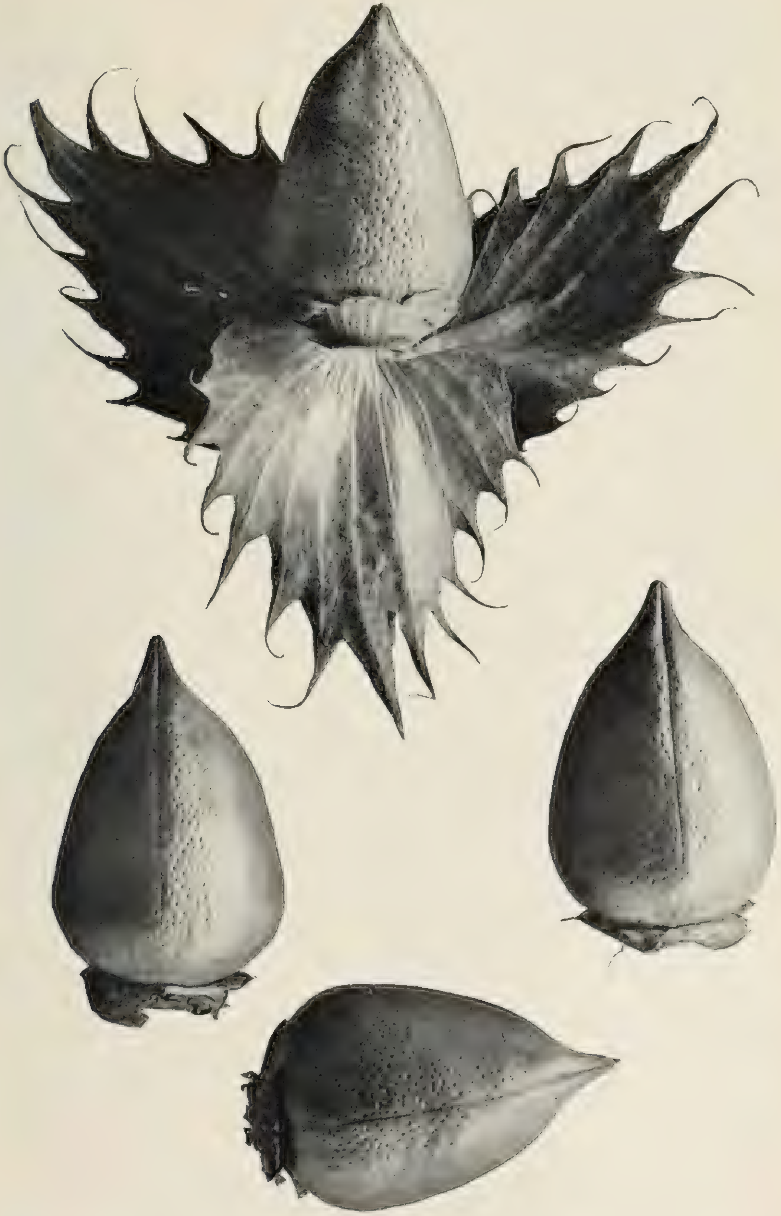


FIG. 2.—EGYPTIAN-UPLAND HYBRID. A MODERATELY LARGE AND FERTILE PLANT.



BOLLS AND INVOLUCRAL BRACTS OF MIT AFIFI EGYPTIAN COTTON GROWN IN ARIZONA.

(Natural size.)



BOLLS AND INVOLUCRAL BRACTS OF EGYPTIAN-UPLAND HYBRID COTTON WITH STRONG RESEMBLANCE TO UPLAND PARENT.

(Natural size.)

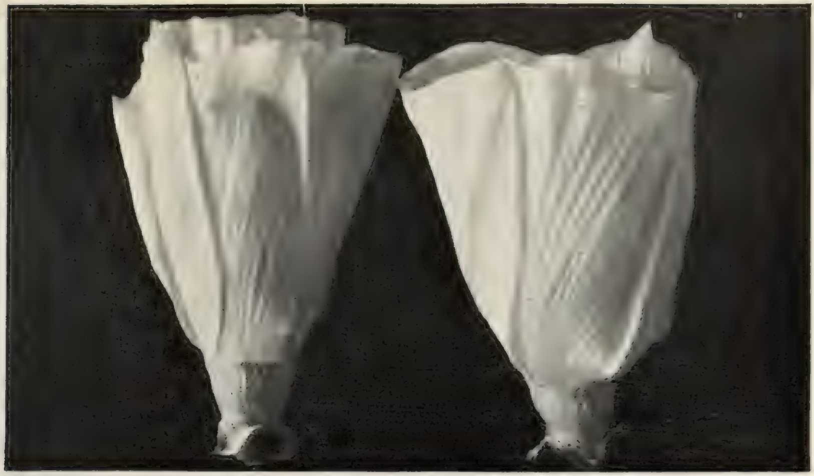


FIG. 1.—FLOWER OF EGYPTIAN COTTON AND FLOWER OF EGYPTIAN-UPLAND HYBRID.
(Natural size.)

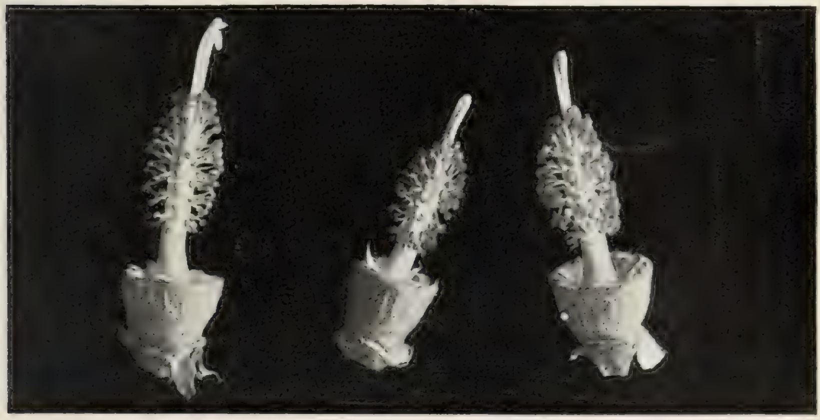


FIG. 2.—STAMENS AND STIGMAS OF EGYPTIAN COTTON.
(Natural size.)

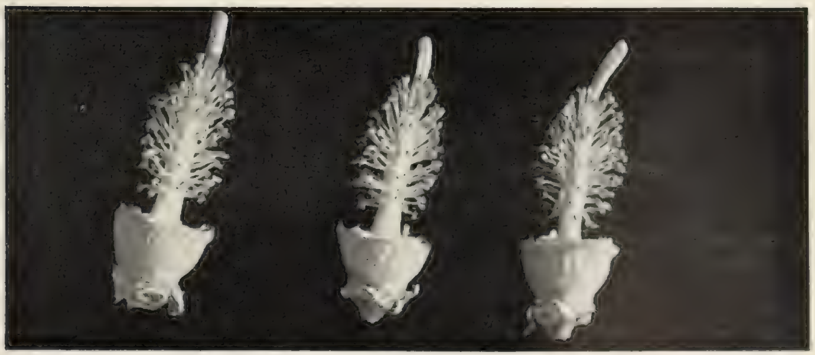


FIG. 3.—STAMENS AND STIGMAS OF EGYPTIAN-UPLAND HYBRIDS.
(Natural size.)

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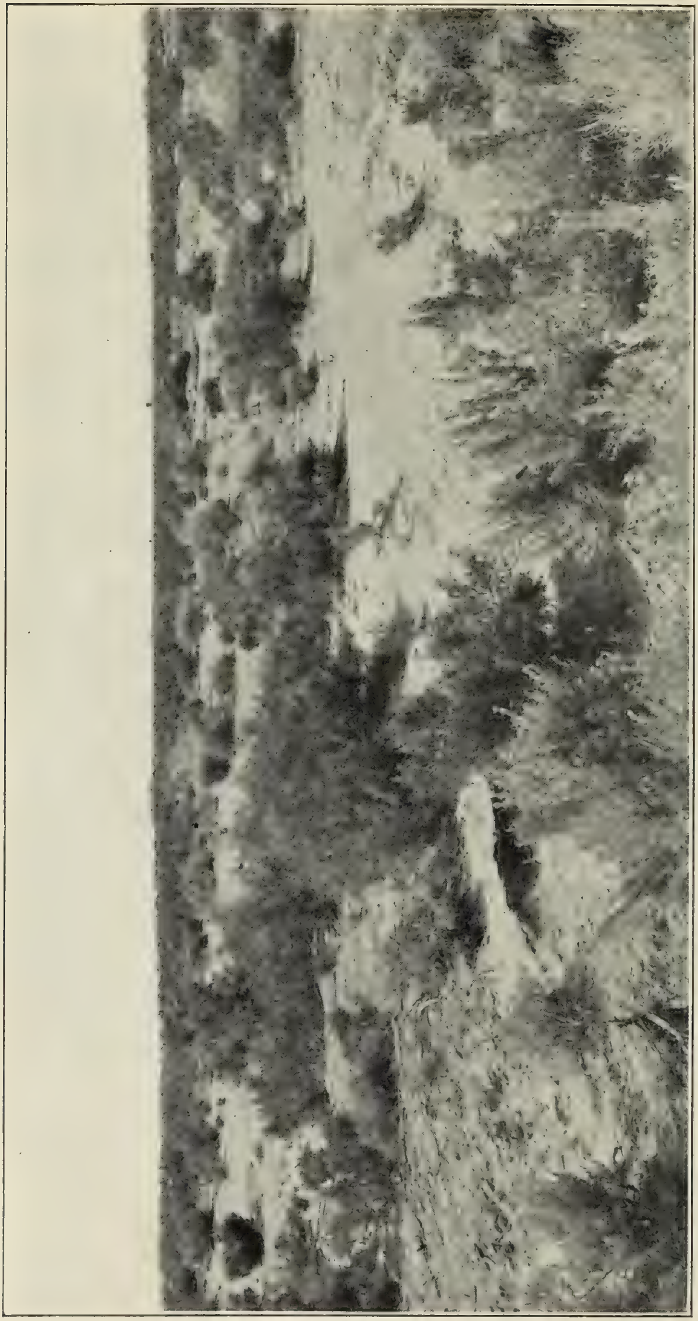

VIEW ON THE TRUCKEE-CARSON RECLAMATION PROJECT, SHOWING THE NATIVE VEGETATION TYPICAL OF THE DESERT LANDS.

(Photographed August 27, 1907.)

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 157.

B. T. GALLOWAY, *Chief of Bureau.*

THE TRUCKEE-CARSON EXPERIMENT FARM.

BY

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AND

SHOBER J. ROGERS, Farm Superintendent,
Western Agricultural Extension.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., May 7, 1909.

Sir: I have the honor to transmit herewith a report entitled "The Truckee-Carson Experiment Farm," by Mr. Carl S. Scofield and Mr. Shober J. Rogers, and to recommend that it be published as Bulletin No. 157 of the series of this Bureau.

The Truckee-Carson Experiment Farm has been established at the request of the Reclamation Service of the Department of the Interior and is one of the several field stations recently established on certain of the reclamation projects in the western United States. It is the purpose of these field stations to enable the investigators of the Department to carry out experiments and investigations bearing upon the agricultural problems of these irrigated sections, to test new crops, and to aid the farmers in successfully meeting their new conditions.

The present report deals with the agricultural situation on the Truckee-Carson project and with the lines of work so far undertaken on the experiment farm.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—478.

THE TRUCKEE-CARSON EXPERIMENT FARM.

INTRODUCTION.

The Truckee-Carson Experiment Farm was established in the autumn of 1906 by the Bureau of Plant Industry of the United States Department of Agriculture, in cooperation with the United States Reclamation Service and the Nevada Agricultural Experiment Station. The farm is located 1 mile south of Fallon, Nev., the principal town on the Truckee-Carson Reclamation Project.

This experiment farm is intended to serve as a place where the agricultural problems of the Truckee-Carson Project may be worked out under the direction of the specialists and experts of the United States Department of Agriculture and the State experiment station of Nevada. In so far as these experts and specialists are acquainted with local problems and are prepared to make definite recommendations, these recommendations are carried out on the experiment farm as demonstrations. Every effort is made by the management of the farm to keep in close touch with the farmers of the community, to understand their problems, and to bring these to the attention of the specialists best qualified to deal with them. It is also the aim to help the farmers in every way possible by securing information for them, by carefully testing varieties of crops, trying new crops, and by comparing different methods of tillage and irrigation.

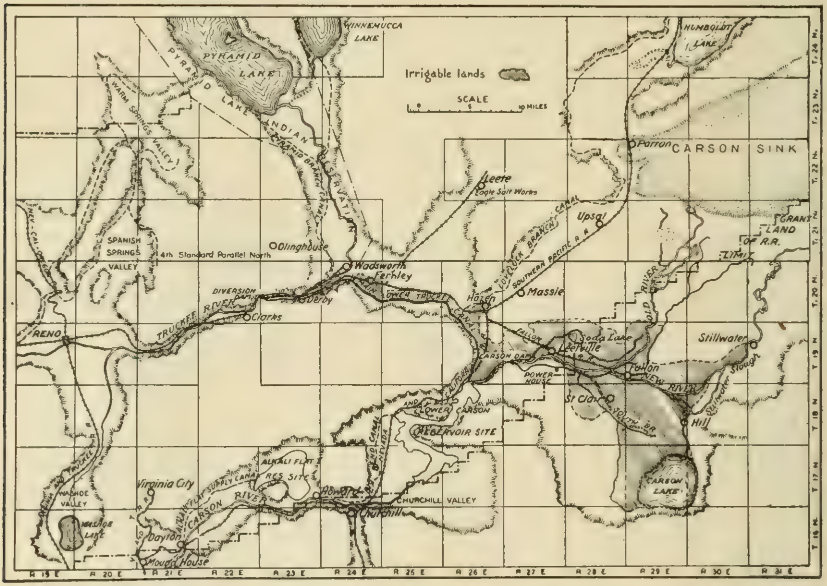
It is not the aim to operate this as a model farm, nor primarily as a demonstration farm. The region is new, agriculturally, and the body of knowledge available is too limited to warrant extensive demonstrations which are unsupported by experiments.

In the following pages there is given a brief description of the region from an agricultural standpoint, something of its agricultural possibilities and limitations, and an account of the lines of work under way on the experiment farm.

DESCRIPTION OF THE REGION.

The Truckee-Carson Project lies near the western edge of a great valley in western Nevada, a depression that was once the bed of a lake similar to the Great Salt Lake of Utah. This lake bed has been named by geologists the Lahontan basin. All that now remains are a few small isolated lakes and marshes. The major portion of this lake bed is a desert. It lies close to the eastern slope of the Sierra Nevada Mountains, which, rising to a height of 12,000 feet or more, catch much of the moisture borne inland by the air currents from the Pacific Ocean. So effectual is this mountain barrier in intercepting these moisture-laden currents that the rainfall in the valley is little more than 2 inches a year.

The valley floor lies at an altitude of about 4,000 feet above sea level. The topography is somewhat rough, being broken by high buttes and small groups of hills, which are often skirted by shelving terraces, while in the intervening flats there are many small sand hills formed by the wind.


WINNEMUCCA LAKE
PYRAMID LAKE
PYRAMID LAKE INDIAN RESERVATION
PYRAMID BRANCH CANAL
WARM SPRINGS VALLEY
Irrigable lands
SCALE
10 MILES
HUMBOLDT LAKE
Parran
CARSON SINK
Leete
Eagle Salt Works
Upsal
LOVELOCK BRANCH CANAL
SOUTHERN PACIFIC R.R.
GRANT LAND OF R.R. LIMIT
SPANISH SPRINGS VALLEY
4th Standard Parallel North
Olinghouse
Wadsworth
Ferhley
LOWER TRUCKEE
Hazen
Massie
OLD RIVER
NEV.-CAL.
DIVERSION DAM
TRUCKEE RIVER
Derby
Clarks
RENO
CANAL
FALLON
Soda Lake
Leeteville
CARSON DAM
POWER-HOUSE
Fallon
NEW RIVER
Stillwater
Stillwater Slough
St Clair
SOUTH BR
Hill
CALIFORNIA AND LOWER CARSON
RESERVOIR SITE
ALKALI FLAT
ALKALI FLAT SUPPLY CANAL
RES SITE
NEVADA CANAL
Virginia City
CARSON RIVER
Howard
CHURCHILL VALLEY
Churchill
WASHOE VALLEY
WASHOE LAKE
Dayton
Mound House
CARSON LAKE
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T. 16 N.

FIG. 1.—Map showing the location of the Truckee-Carson Reclamation Project and adjacent territory.

Into this valley from the west flow two important rivers, the Carson and the Truckee. These are fed by the rain and melting snow of the high Sierras. The combined water of these two rivers is used to irrigate the body of land known as the Truckee-Carson Project.

The construction work necessary to distribute this water for irrigation has been done by the Federal Government under the authority of the reclamation act, approved June 17, 1902. Of the 350,000 acres of irrigable land included in this project, some is held in private ownership by early settlers, some is offered for sale by the Southern Pacific Railroad Company—being a part of the land grant to that company—some has been filed upon by new settlers under the homestead law as modified by the reclamation act, and some is still open for entry. The accompanying map (fig. 1) shows the location of the project and some of its more important topographic features, as well as some of the cities and towns included or adjacent.

CLIMATE.

Table I, compiled from the records of the United States Weather Bureau, shows approximately the temperature conditions that exist in the region under discussion. It will be noted that the maximum temperature recorded for four years is 103° F., while the minimum is −2° F. During the winter of 1907–8 the lowest temperature reached was 12° F.

TABLE I.—*Mean, maximum, and minimum temperatures at Fallon, Nev., for four years, 1904–1908.*[a]

Month.	1904.			1906.			1907.			1908.		
	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.
	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
January	26.9	56	0	31.7	60	6	30.7	64	−2	34.8	56	12
February	38.2	65	9	40.7	69	11	45.4	72	22	38.6	71	16
March	43.8	69	15	......	......	......	42.4	70	12	42.6	78	15
April	49.4	83	20	50.5	84	18	54.8	81	29	52.6	89	18
May	58.4	85	28	56.6	84	31	56.3	88	29	51.6	80	25
June	66.0	93	39	63.4	90	38	62.0	93	33	62.8	93	35
July	73.7	98	48	78.2	101	53	72.0	99	44	76.4	101	51
August	......	......	......	74.6	98	42	69.2	99	40	72.2	103	36
September	......	......	......	62.8	90	34	60.1	95	29	61.5	94	26
October	51.3	76	30	52.3	88	22	......	......	......	48.6	82	15
November	......	......	......	37.8	81	−1	39.8	76	18	40.7	68	6
December	......	......	......	35.9	59	−2	37.7	72	15	28.8	56	−2

[a] The records of temperature at Fallon for 1905 are not obtainable.

The length of the summer period between frosts is shown in Table II. The stations to which the records apply are located in different parts of the region (see map, fig. 1), and it will be noted that there are some marked differences in the frost dates recorded. The variation in topography may account for some of these differences, but it is probable that there are also errors in observation due to the inexperience of the observers.

TABLE II.—*Dates on which the last killing frost in spring and the first killing frost in autumn occurred, as reported by voluntary observers at points on the Truckee-Carson Project, 1905–1908.*[a]

Year.	Frost.	Carson dam.	Leetville.	Soda Lake.	Fallon.	Hazen.	Fernley.
1905	Last	......	......	......	......	......	......
	First	......	......	......	......	Oct. 8	......
1906	Last	......	......	......	May 31	May 28	......
	First	Sept. 4	Oct. 4	Oct. 18	Oct. 4	Oct. 18	......
1907	Last	Apr. 20	May 2	......	May 14	June 15	June 14
	First	Oct. 29	Sept. 19	Sept. 18	Sept. 19	......	Oct. 4
1908	Last	May 15	May 9	May 16	May 30	......	May 8
	First	Sept. 26	Sept. 26	Sept. 25	Sept. 25	......	Sept. 26

[a] Compiled from official reports of the U. S. Weather Bureau.

The rainfall of the region is so slight as to be negligible as a factor in supplying moisture for crops. The records available show an annual mean precipitation of about 2.5 inches, of which the major portion falls in the winter months.

Observations as to the atmospheric humidity are too inadequate to be of value, but it may be said that the air is usually very dry. During the past year observations have been made as to the quantity of water evaporated from a free-water surface. The results are given in Table III.

TABLE III.—*Quantity of water (inches in depth) evaporated from a free water surface near Fallon, Nev., 1908.*[a]

May.	June.	July.	August.	September.	October.	November.	December.
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
7.91	10.22	11.74	10.84	5.50	4.00	2.27	0.65

[a] The figures shown in Table III were obtained at the experiment farm from a tank installed for the purpose of measuring the evaporation. This tank is made of galvanized iron, 4 feet in diameter and 2 feet deep. It is embedded in the earth only a few inches. The water in the tank is kept about 18 inches deep.

The wind is often an important factor of the climate in a desert region, particularly where the soil can be easily blown, as is the case on the Truckee-Carson Project. There are no accurate records of air movement for this section, but it has been found by experience that the winds are not of sufficient strength and frequency to justify the use of windmills for pumping the farm water supply, although the wells are all very shallow. Notwithstanding this fact, windstorms of considerable violence are likely to occur during the spring, and they may do considerable damage in drifting the soil from newly leveled or otherwise unprotected fields. On this account new settlers on the lighter soils find it necessary to use care in removing the brush and leveling land.

Wind-breaks of tamarisk and cottonwood should be started on new farms as soon as water is available and before any large proportion of the native brush cover is removed. Both of these trees are well suited to this locality. They may be propagated by cuttings, and grow vigorously from the first.

WATER SUPPLY.

The water supply used in irrigating this project is obtained from the Carson and Truckee rivers, which rise on the eastern slope of the Sierra Nevada. The water of the Carson River is directly diverted for use on the project, and the water of the Truckee is carried through a long canal and delivered into the Carson at a point in that river above the dam diverting to the irrigation ditches. The Carson River drains the lower foothills of the mountains, and its water supply is usually exhausted by midsummer. The Truckee, on the other hand, takes its rise in Lake Tahoe, high in the mountains, and consequently its discharge is more regular throughout the season. Both rivers, however, are subject to high floods, so that a considerable quantity of water is wasted in the spring months. Additional construction work is contemplated to provide storage reservoirs in order to save as much of this flood water as possible to supplement the midsummer flow of the streams. At present the irrigable land on the project somewhat exceeds the water supply during the late summer.

The system of water distribution on the project carries the water to each farm unit. The farm units are usually 80 acres in size, except near the towns, where they are 40 acres. A prospective settler selecting a farm unit, not already filed upon, will make homestead entry in the usual way, paying the usual fees and commissions and one installment of the charges which are assessed to cover the cost of the construction by which the water is furnished, and the cost of maintaining the distributing system. The construction cost on the project is now $30 per acre of irrigable land, which is payable in not more than ten annual installments. In addition to the construction charge there is an annual charge for maintenance and operation of 60 cents per acre of irrigable land. When the usual requirements of the homestead law have been complied with and one-half of the irrigable area has been reclaimed and the construction and other charges are fully paid, the homesteader secures a patent to his land and owns also the permanent water right which attaches to it.

DRAINAGE AND UNDERGROUND WATERS.

The main body of the irrigable land lies in the valley of the Carson River. This stream previous to its use for irrigation purposes flowed out into the desert, emptying partly into Carson Lake and partly into Carson Sink, where the waters evaporated. The river's course was a meandering one, and its channel changed from time to time as a result of flood modifications. In addition to the channel flow there was a very considerable movement of underground water through porous strata a few feet below the surface of the ground. This underflow has become a factor of considerable importance. In the lower places it is often so near the surface that capillary connection is established, and evaporation from the surface soil leaves deposits of salt. Since the normal flow of Carson River has been supplemented by water from the Truckee and both are distributed over the land for irrigation, this underflow has been somewhat increased and the underground water table has risen slightly, causing considerable anxiety among settlers on the lower land on account of possible trouble from alkali. When the system of distribution was installed a system of drainage ditches was also put in throughout the lower lands. When this drainage system is perfected it will probably be adequate to keep the water table below the point where it can cause serious and extensive damage.

MARKETS AND RAILROAD FACILITIES.

In view of the fact that a relatively large body of land, hitherto unused, is rapidly being made productive, the need of suitable markets for the agricultural products becomes acute, and consequently the question of the railroad facilities of the region is an important matter.

The Truckee-Carson Project lies immediately adjacent to the main line of the Southern Pacific, between San Francisco and Ogden. A short branch line of this railroad extends from Hazen, which is a junction point on the main line, to Fallon, the principal town of the project. From Hazen a railroad also runs south into the Goldfield and Tonopah mining districts, and thence southeastward to connect with the San Pedro, Los Angeles and Salt Lake Railroad. Direct railroad communication is therefore possible, not only with the large markets of California, but also with the large mining towns of Nevada. These mining towns have practically no agricultural lands immediately adjacent to them; hence, they are good markets for all kinds of agricultural products, and prices are high. There are also a number of mining camps in the hills south and east of the project to which the railroad has not yet been extended. These camps also, having no local food supply, are good markets for products raised on the project.

AGRICULTURAL CONDITIONS.

The agricultural lands of the Truckee-Carson Project may be conveniently divided into two distinct classes. One class consists of the lands lying close to the river and slough channels and along the border of Carson Lake. All these lands, regardless of their mechanical texture, carry a considerable amount of organic matter and are consequently very fertile and, where not too wet, are capable of immediate crop production. The other class comprises the more truly desert lands, which are conspicuously devoid of organic matter and which require special treatment before they reach a condition of maximum crop production.

Two distinct soil types are found in the desert lands. One type is a very sandy soil which, when exposed, is easily drifted by the wind. The other is known locally as "hard land," or "clay flats." There is, of course, considerable variation in the mechanical texture of both types. Some of the soils are nearly pure coarse sand, while others carry a large quantity of fine material and verge on a sandy loam. The soil of the hard lands, or clay flats, is often a mixture of rather coarse sand and clay, containing some cementing material. Both soil types are irregularly distributed throughout the project, sometimes occurring in small areas side by side. But the sandy soil is by far the more extensive in the aggregate, sometimes occupying large areas to the exclusion of the hard lands. A soil survey of the project is about to be started by the Bureau of Soils. When that is completed more exact information will be available on the classification, location, and extent of the soil types.

While the soils along the river channels and lake bed present few obstacles to securing immediate crop production the reverse is true of the desert soils. These latter do not respond immediately to tillage and irrigation as desert soils are popularly supposed to do. It is true that a part of their apparent infertility may be due to a variety of extraneous causes; for instance, crop failures are sometimes due to windstorms or nonadaptability of the crop tried. It is certainly true, however, that considerable care is necessary in handling these desert soils to insure crops the first season or two. After they have been irrigated and cultivated for a time they become very productive.

NATIVE VEGETATION.

The soils along the river channels and around Carson Lake support a relatively luxuriant native growth, the most conspicuous features of which are the cottonwood trees, the willows, sagebrush, rabbit brush, wire-grass (species of the genus Carex), a number of sedges, and some tules, chiefly cat-tail. In a few areas some clovers (species of the genus Trifolium) and one or two species of vetch occur. There are considerable areas occupied almost exclusively by tall grasses, chiefly Elymus.

The vegetation of the desert is much less abundant, both in amount of growth and in species represented, than that of the river-bottom land. No trees occur on the desert soils. The chief elements of the vegetation are greasewood (Sarcobatus), sagebrush (Artemisia), and rabbit brush (Chrysothamnus). There is also a considerable variety of small annuals which spring up and flourish after the rains, among them the so-called desert verbena (Abronia), one or two species of Astragalus, and a few grasses. (See Pl. I.)

EARLY SETTLEMENT.

The first agricultural development of this region began about the middle of the last century, when there was some use of the Carson River water on the land immediately adjacent to it. This agriculture was limited in extent, and was mostly connected with stock raising on the range lands in the adjacent hills. The irrigated land was held in large bodies, and was used chiefly for the production of hay and grain. As the Carson River usually went dry before midsummer, it was unsafe to depend upon crops requiring water late in the season.

Upon the completion of the present irrigation project, in 1906, a considerable extension of farming immediately took place. New settlers came in, some of whom bought land which had previously been under ditch and others took homesteads on the desert land. The recent extension of mining enterprises in the adjacent hills has made a good market for vegetables and truck crops, while the presence of the work stock used in the valley for ditch construction and for opening the new lands for farming has caused large demands to be made for grain and forage, so that up to the present prices for agricultural products have been good. The extension of farming to the desert lands has brought up many problems of the utmost importance to the new settlers, some of which may be solved by experience elsewhere, but many others must be worked out locally to insure correct solution. It is for the purpose of helping these new settlers that the Truckee-Carson Experiment Farm has been established.

CLEARING AND LEVELING THE LAND.

One of the problems which confronts a new settler, after his land has been selected and his buildings put up, is the clearing and leveling of his land. There are a number of ways in which this can be done, depending upon the equipment available. One of the most economical ways is first to go over the land with a railroad rail, with a team at either end. This breaks down the brush, snapping off the brittle stems of the desert shrubs. This brush can then be forked into piles and burned, or hauled off the field, to be used as fuel. The land is then plowed with a heavy breaking plow, or sometimes leveled with a scraper without plowing.

There is a diversity of opinion as to the best method of preparing land for irrigation. The most economical method on this project is to throw up borders which conform somewhat to the natural topography, forming checks of various shapes which can be flooded from the ditch which is carried along the high contour line. Some of the land is so nearly level that regular checks can be made by throwing up borders and smoothing off the occasional sand hills which occur. In view of the danger from wind action mentioned, it is very important to leave uncleared any land which is not to be immediately leveled and irrigated. On the sandier soils it will often be found advisable to clear and level the land in relatively narrow strips, leaving the brush-covered land between to break the force of the wind until artificial wind-breaks may be provided.

The matter of wind-breaks should be given the earliest attention by the new settler. Not only should trees and shrubs be planted to shelter the fields, but the house and the corral should also be provided with a shelter of trees. These will furnish shade and protection from the wind, both of which are very necessary to comfort, besides improving the appearance of the place. Cottonwoods, honey locusts, black locusts, Russian olives, and tamarisks should be used abundantly both around the farmstead and along the ditch lines. Not only are trees valuable for wind-breaks and shade purposes, but they will soon furnish fuel, which is now and probably will continue to be very high priced. Indeed, the fuel situation is so acute that every effort should be made by the farmers, both individually and as a community, to secure the planting of extensive areas to trees. Scattered over the project there are a number of areas of relatively little value for agricultural purposes upon which trees would grow rapidly, and time should not be lost in getting trees started where-ever possible.

THE FIRST CROPS.

The first crops on new land in this region are usually grain, alfalfa, and vegetables. Alfalfa, though often a little difficult to start, thrives well when once established and ranks as the most important crop of the region. On land which contains any appreciable quantity of organic matter there is little or no difficulty in growing alfalfa if the land is in good tilth when the seed is sown. Alfalfa can be sown at almost any season of the year, but does best when sown either in April or in August. On new land, where organic matter is deficient or absent, and particularly where there is danger from sand storms, the best success in starting alfalfa is secured where wheat or barley is sown as early in the spring as weather conditions will permit, which is some time in March. When the grain is a few inches high the alfalfa is sown in it with a drill. The grain serves as a protection to the young alfalfa plants, both from the wind and the sun, and also tends to prevent crusting of the surface soil, which is a serious matter, particularly on the hard lands. For the best results with alfalfa it is desirable to cut the grain for hay before it is quite mature. This early cutting gives the alfalfa a chance to make good growth before cold weather sets in.

Wheat, oats, and barley are all used for grain. Winter wheat can be sown in the fall, and it is probable that some varieties of winter barley may be found that will thrive well, but so far no adequate tests have been made upon which to base recommendations as to the best varieties of this or of any other cereal. Where land is not ready for seeding in time for wheat or oats, sorghum or millet could be grown for forage. The amber varieties of sorghum and the German millets promise the best results.

POSSIBLE AGRICULTURAL INDUSTRIES.

In considering the possible agricultural industries of this, as well as of any other region, the most important factors, aside from the natural conditions, are the present and future marketing facilities, labor supply, and the inclinations of the people themselves. The present indications are that some form of live-stock industry must occupy a large place in the future agriculture of the Truckee-Carson Project.

TRUCK CROPS.

For the present and for some little time to come truck crops of the heavier class, such as potatoes, onions, cabbage, and the root crops, will be important features. However, these are relatively intensive industries, and there is hardly a sufficient market at hand or in sight to justify the use of the major portion of the irrigated lands of this project for such crops. It is hardly probable that these crops can be produced to compete in the California markets with similar crops grown in the San Joaquin and Sacramento valleys, and certainly it is not to be expected that under existing conditions they can be profitably sold in the markets farther east.

STOCK RAISING AND DAIRYING.

Some form of stock farming, however, may be expected to provide use for all the land now irrigable in this region, and even for a very considerable extension. With dairying, for instance, as the major industry of this project a number of subsidiary industries might very well be given considerable emphasis. Butter is a concentrated and high-priced product on which freight is a relatively small item.

With the increase of forage production on the project it would be more profitable for farmers to feed their forage and grain to dairy cows than to attempt to ship it out of the country. Once an abundant supply of forage and grain can be provided, cooperative creameries should be organized when the necessary cows are available. It is very important, however, that this industry should grow up gradually. Many costly mistakes can be made by rushing into the dairy business too rapidly. Dairy cows must be bred on the project. They can not be profitably purchased in sufficient numbers to warrant the establishment of a large industry. Men must learn to cooperate in the creamery business before they can hope to succeed, and, above all, good machinery and good butter makers must be secured. Without these it is useless to expect high prices for the product. It is also necessary before any extensive dairy business can be built up to provide pastures in addition to the alfalfa hay lands. For this purpose the proper kinds of grasses must be found and proper methods learned for establishing the pastures. There is every indication that good grass pastures can be established and maintained on the project. These pastures, supplemented by corn, barley, oats, and root crops, all of which can be grown profitably, will furnish a food supply for dairy stock which should be both cheap and adequate. With the dairy industry as a center a number of intensive subsidiary industries may be developed.

FRUIT RAISING.

In addition to the truck crops already mentioned there is every reason to believe that a considerable number of small fruits can be produced with profit, and the meager information at hand would indicate also that a number of orchard fruits, such as apples, pears, and plums, might be profitable as side lines on many farms. It is important to keep in mind, however, that these industries to be most profitable must be subsidiary to the main farm operations. It is hardly to be expected that the Truckee-Carson Project will prove exceptionally well suited to fruit or truck-crop production for some time to come.

SUGAR BEETS.

Another industry which at present, at least, should be considered as a subsidiary one is the production of sugar beets. Experiments indicate that sugar beets of excellent quality can be grown on this project. Sugar-beet growing, however, demands the erection of an expensive factory, and it also requires a considerable amount of hand labor, so that it is hardly to be hoped that sugar-beet production on an extensive scale will be developed on this project in the near future.

SUBSIDIARY PRODUCTS.

There are many other lines of production, both of crops and of live stock, that suggest themselves as being of good promise in a subsidiary way. The production of early lambs and hog raising are lines that go hand in hand with the general farming to which this region seems best adapted. At the present time the supply of eggs and other poultry products is far below the demand. Growers who make a specialty of the fancy truck crops are also needed to supply the local and adjacent markets. Every farmer should keep in mind that prices of farm products are regulated by the law of supply and demand. Specialization and rapid extension in the production of any but staple products are likely soon to flood the market and result in much wasted effort.

THE EXPERIMENT FARM.

The experiment farm is located 1 mile south of the town of Fallon. It includes 160 acres, and its soil is typical of a large part of the desert land of the project, both the sandy and clay lands being well represented. None of the river-bottom or slough land of the project is included in the farm. The topography is rough and probably one-fourth of the land lies above the level of the supply ditch.

When work was begun on the farm in September, 1906, there were no fences or improvements of any kind and the land lay untouched in its native desert condition. Since that time 40 acres of land have been leveled and put under ditch. The farm has been fenced and equipped with two small dwellings, an office building, and a barn and machine shed. A working equipment of farm machinery has been purchased and the necessary work animals have been hired as needed.

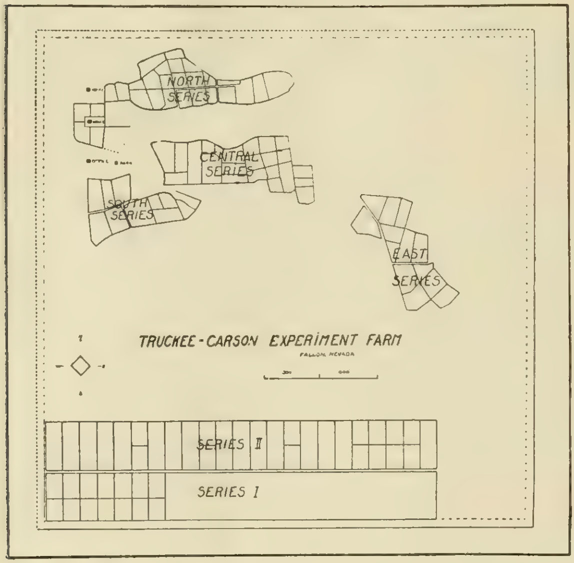

Fig. 2.—Diagram showing the location of the fields and farm buildings on the Truckee-Carson Experiment Farm.

The accompanying map of the farm (fig. 2) shows the fields that were available for use during 1908 and the location of the farm buildings. Additional land is being leveled and prepared for use as opportunity offers. The working force of the experiment farm consists of a superintendent and two or three laborers.

THE "HARD LANDS," OR "CLAY FLATS."

In view of the fact that the clay flats which occur on the farm and elsewhere throughout the project appeared to present one of the most serious difficulties likely to be met with by the new settlers, experimental work was begun on 15 acres of land on the farm, which lie on this soil type. The land was first leveled and put into checks of one-half and one-fourth acre each, and a number of different methods of treatment were used in preparing the seed bed and putting in the crops. A large variety of crops were also tried the first year, many of which failed completely. Through these experiments much was learned as to what to do and what not to do in handling this soil. In its native condition this soil is almost entirely devoid of vegetation, that which does occur being limited to the small sand knolls which are found here and there.

Table IV gives the results of the mechanical analyses of a number of samples of soil taken from various parts of the hard land of the experiment farm. A number of these samples show a large percentage of fine gravel and coarse sand, and correspondingly small percentages of the finer materials. These samples represent the sand knolls, and though the figures show a marked difference in the physical structure of the soil this difference can hardly be detected in working the soil in the field, particularly so far as initial productivity is concerned. In fact, the lack of correlation between the results obtained from the mechanical analyses and the behavior of the soil in the field makes it evident that there is some cause other than mechanical texture which makes this soil so difficult to handle.

TABLE IV.—*Results of the mechanical analyses of samples of soil typical of the clay flats on the Truckee-Carson Experiment Farm.*[a]

Depth.	Hole.	Fine gravel (2–1 mm.).	Coarse sand (1 to 0.5 mm.).	Medium sand (0.5 to 0.25 mm.).	Fine sand (0.25 to 0.1 mm.).	Very fine sand (0.1 to 0.05 mm.).	Silt (0.05 to 0.005 mm.).	Clay (0.005 to 0 mm.).
Inches.	*No.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
0–12	1	5.3	24.4	23.7	32.4	3.9	3.2	6.4
0–12	2	1.2	9.5	7.3	30.9	16.0	18.4	16.3
0–18	7	.7	7.0	8.2	37.4	15.6	17.2	14.1
0–32	9	.9	5.5	5.3	21.1	6.8	27.9	32.2
0–20	19	2.0	10.2	9.4	41.5	9.4	7.9	19.4
0–12	22	3.1	16.4	12.9	34.7	10.3	8.2	14.3
0–12	23	.8	8.2	12.4	49.7	10.5	6.2	12.4
0–24	24	2.9	6.5	5.2	22.8	11.9	26.1	23.9
0–32	25	.4	2.4	2.9	30.4	22.4	22.6	19.2

[a] Analyses made by the Bureau of Soils, U. S. Department of Agriculture.

It has been noted that the desert soils, of which the experiment farm is typical, are generally deficient in organic matter. It is believed that much of the apparent infertility and other difficulties found on the hard lands are due to the lack of this constituent. Analyses made of four samples of soil from different parts of the hard land on the experiment farm showed the following percentages of organic matter:

TABLE V.—*Results of analyses, showing the percentages of organic matter in samples of soil from the clay flats of the Truckee-Carson Experiment Farm.*[a]

Depth of sample.	Hole.	Organic matter.
Inches.	*No.*	*Per cent.*
0-12	1	0.19
0-12	2	.31
0-32	9	.56
0-20	19	.17

[a] These determinations of organic matter were made by Miss J. R. Pearce. The soil samples were first digested with strong HCl to remove the carbonates, then heated to redness in the presence of oxygen, and the CO_2 formed was collected in caustic potash and weighed.

In order to make a comparison, it may be said that fertile soils rarely contain less than 1 per cent of organic matter, while rich prairie soils often contain much more. According to Hilgard,[b] the prairie soils of North Dakota contain in the first 6 inches from 15 to 26 per cent of organic matter, with a humus content ranging from 4 to 7.8 per cent. Soil samples from Dalhart, Tex., where the climate is semiarid and the soils are regarded as deficient in organic matter, show by the same method as that used in analyzing the Fallon soils slightly over 1 per cent of organic matter.

A chemical analysis, after acid digestion made upon seven samples of soil from a typical tract of hard land near the experiment farm, shows the following results, the figures being the average of those obtained from the seven analyses which were made by the Bureau of Soils: Phosphoric acid (P_2O_5), 0.17 per cent; lime (CaO), 1.71 per cent; magnesia (MgO), 1.40 per cent; potash (K_2O), 0.82 per cent.

The prompt subjugation of this hard land, where no troubles with alkali are involved, will require the use of some farm implements not usually found on western farms. The aim should be to get a good mellow seed bed established without turning up the raw subsoil, and particularly to keep the surface soil mellow and fine until the crops are high enough to shade the ground. This latter aim is very important. For preparing a fine, mellow seed bed, the disk, a turning and slicing harrow, and the ordinary spike-toothed harrow make a very satisfactory combination of implements. Sometimes the corrugated roller (see Pl. II, fig. 1) will do much better work after the turning and slicing harrow than the smoothing harrow. For keeping the soil surface mellow and warm after the crops are planted and until they are high enough to shade the ground the corrugated roller and the steel-toothed weeder do the work very well. The corrugated roller

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[b] Soils, p. 133.

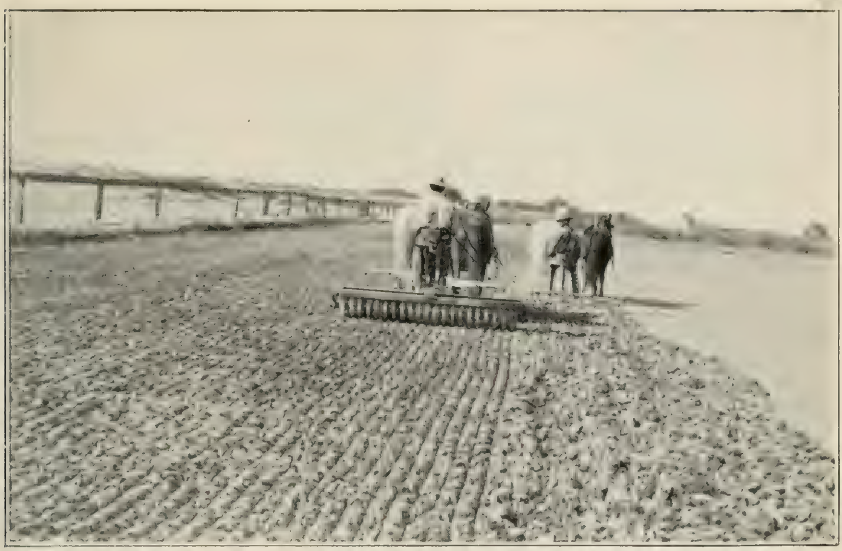

FIG. 1.—A TURNING AND SLICING HARROW, FOLLOWED BY A CORRUGATED ROLLER, IN USE IN PREPARING A SEED BED ON THE "HARD LAND" OF THE TRUCKEE-CARSON EXPERIMENT FARM. (PHOTOGRAPHED AUGUST 25, 1908.)

This land had been previously irrigated by flooding and a hard crust had formed, which these implements are effectually breaking up.

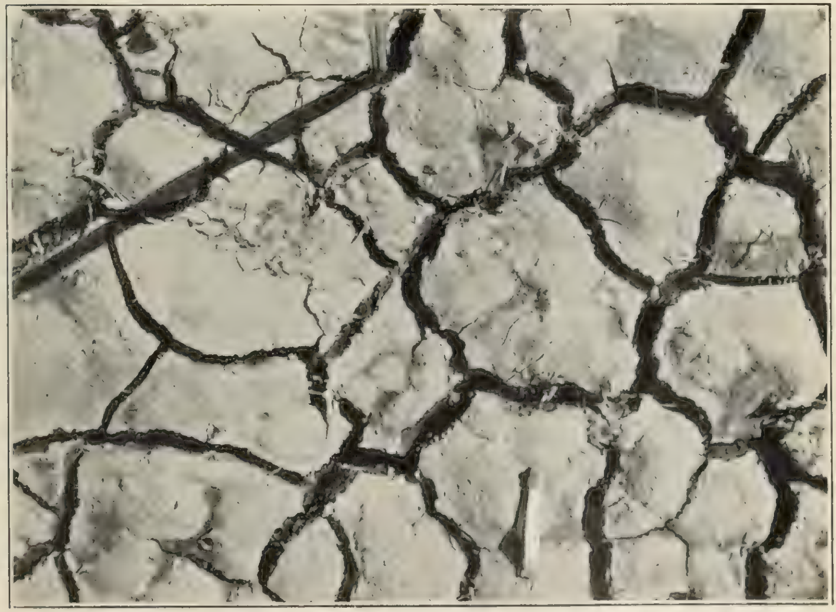

FIG. 2.—SURFACE OF THE "HARD LAND," SHOWING HOW THE SOIL BAKES AND CRACKS WHEN IT DRIES UNDISTURBED AFTER IRRIGATION.

Small plants are either killed or severely injured in this soil unless this baking and cracking can be prevented by cultivation.

seems to be absolutely essential for this work. The harrow or the weeder alone will not do. The roller can be used without injury to the small grains until the plants are 4 or 5 inches high. Following the roller the weeder does very excellent work, fully repaying its cost even on a small acreage.

It has been found that in order to get satisfactory results from this soil it should not be stirred deeper than is absolutely necessary to get a seed bed. Deep plowing or removing the surface soil for leveling purposes results in bringing to the surface soil which is very infertile and difficult to work. If the surface soil is not buried in the preparation of the seed bed, much better results are secured.

The hard land takes water very slowly, and during an ordinary flooding is not penetrated to a depth of more than 6 or 8 inches. It was found, in fact, that on some plats after an entire summer, during which the land was irrigated at intervals of two or three weeks, there were places where moisture had not penetrated beyond 18 inches and where the soil was so hard that holes could be dug only with the greatest difficulty.

In some cases the soil on these clay flats contains alkali, but this is by no means always the case; in fact, the larger part of the trouble with these soils seems to be due to their mechanical rather than to their chemical composition.

The relative impenetrability of soils of this hard land is well illustrated by an investigation made in an alfalfa field adjacent to the experiment farm. The field as a whole was fairly good, but it contained a number of spots irregular in size and shape, where the alfalfa plants were only from 3 to 6 inches high, while on the remainder of the field the plants grew to a height of 30 inches or more.

The boundaries of these areas of poor growth were found to be sharply defined. Thus, in a distance of 4 feet plants would increase in height from 3 to 30 inches. An examination of the poor spots, as compared with the areas where the growth was good, showed that in the poor spots the alfalfa roots did not penetrate beyond 10 inches, while on the land where the alfalfa was good the roots penetrated to a depth of 3 feet or more. The roots of the small plants were apparently unable to penetrate the hard soil beyond the depth of 10 inches. At this point many of the taproots branched and spread out irregularly, instead of pushing on into the subsoil as they usually do.

A careful comparison of the soils on the good and poor spots in this field showed that the soil of the poor spots was very slightly finer in texture, containing a larger proportion of clay. It was apparent, however, that the chief difficulty on these poor spots was that the irrigation water had not penetrated beyond the depth to which the roots were found to have extended, and only the upper 8 inches was found to be wet. Below this depth a layer of soil about 1 foot thick was very hard, the particles being cemented together. Below this hard layer the soil was more open, and at a depth of about 4 feet the underground water was reached.

An examination of this soil to determine the salt content in the good and poor spots brought out the fact that in the good soil the percentage of soluble material was very much lower than in the poor soil, and particularly was this difference marked at the lower limit of water penetration. The indications were that in the poor spots the irrigation water had failed to penetrate the soil to join the water table, and thus carry down the excess salt.

The best results in handling these clay flats are likely to be secured where they are first heavily irrigated, to secure thorough penetration of water, and afterwards given a thorough cultivation. There is apparently nothing to be gained and much to be lost by deep plowing this land, at least until the soil is thoroughly subdued. After a thorough irrigation the soil may be worked into good tilth if the proper implements are used, and if care is taken in getting the crop started there should be little difficulty in securing a fairly good stand of grain or alfalfa on the land the first year.

The aim should be to get organic matter into these soils as rapidly as possible. Green-manure crops and coarse manure should be worked into the soil, and the surface tilth should be kept good to aid decomposition and humus formation. The greatest care should be used in the irrigation and tillage of the hard lands. If possible, the crop should be planted after an irrigation, and should be allowed to grow enough to shade the ground before the second irrigation is given.

Unless the ground is shaded, the crust formed after an irrigation, or even a light rain, is very hard and impervious, and seems to choke the young plants and almost completely check their growth. (See Pl. II, fig. 2.) In breaking this crust when the plants are young the corrugated roller, followed by the horse weeder, does very effective work. These instruments can be used to advantage even when the grain or alfalfa is several inches high.

In view of the obvious need of this hard land for aeration and organic matter it would seem the best practice to get alfalfa started on it as soon as possible. Once established, alfalfa does fairly well, and after this crop the land will certainly be much improved for other crops.

THE SANDY SOILS.

The sandy soils on the experiment farm, as elsewhere in the project, present a very different set of problems from the hard lands. They respond to tillage and with a few exceptions appear to be immediately fertile. They are generally deficient in organic matter, and can be greatly improved by manure or a season or two in alfalfa. They are liable to wind injury and must be kept covered by crop or stubble after the native brush cover is removed. Their water-holding capacity is low and they require frequent irrigation. Water moves through them rapidly, and where the underground water is close to the surface there is danger of the surface accumulation of alkali.

Even the sandy soil forms a thin crust after irrigation unless cultivated, and the evaporation of water from the soil surface after irrigation is very rapid unless the ground is stirred and a surface mulch is made. This surface mulch is extremely important, not only in checking the rise of alkali, but in keeping up the temperature of the soil. A moist soil surface cools the soil just as a moist wrapping cools a water jar. Many crops are extremely sensitive to low temperatures in the spring, and make very slow growth while the soil remains cold. Thorough cultivation as soon as possible after irrigation practically stops evaporation from the soil surface and permits the soil to warm up.

Farmers are inclined to do no more cultivating than is required to keep down weeds. The necessity for weeding is slight on this new land, and it is a serious mistake to limit cultivation to that object alone. The land should be cultivated after each irrigation, whenever possible, whether there are weeds to kill or not.

COOPERATIVE EXPERIMENTS.

Much of the experimental work on the farm is conducted in cooperation with, and under the direction of, various experts and specialists in the Bureau of Plant Industry, in the Forest Service, and in the Nevada Agricultural Experiment Station.

The results of these experiments and investigations will in many cases be published by the men in charge of the work. It will suffice here to give a brief account of the lines of work thus far undertaken, with such of the results as are immediately and directly applicable to local conditions.

FORAGE AND GREEN-MANURE CROPS.

In view of the apparent need of putting organic matter into the soils of the experiment farm, almost the first efforts made in crop production were in the direction of producing forage and green-manure crops, including grasses. These experiments were made in cooperation with Mr. C. V. Piper, of the Bureau of Plant Industry.

A considerable number of these crops were planted in the spring of 1907 on the clay lands of series 1 and 2 (see fig. 2). Redtop, rape, and sweet clover were the most promising of the series. None of the crops tried was thoroughly satisfactory, and it was apparent that on the clay lands only the three mentioned can compete with alfalfa in vigor of growth. It now seems certain that in subduing the clay land the best results may be expected where spring grain and alfalfa are sown and the alfalfa is later plowed under after a good stand has been secured.

In view of the need of pasture lands for work stock and cattle a number of mixtures of grasses were tried in 1907, and again in 1908. The most promising single grass so far tried is redtop. This appears to do very well, not only on the clay lands, but it makes a vigorous growth along the ditch banks and almost anywhere where the moisture supply is adequate. Mixed with perennial rye, slender wheat-grass, and white clover or alsike clover a very good pasture may be established. There are indications, though no absolutely definite information, that artificial inoculation for clover and possibly also for alfalfa will give beneficial results.

SUGAR BEETS.[a]

In the spring of 1907 an acre of land was planted to nineteen varieties of sugar beets. This land was typical of the clay lands, although not of the heavier and most difficult type. In 1908 beets were planted both on the clay land and on the sandy soil. Those on the sandy soil were badly injured by sand storms early in the season and their later growth was seriously checked. On the clay land, however, the growth was good, although the stand was cut down by the ravages of rabbits. This made it impossible to obtain accurate information as to the comparative yields of the varieties, though estimates based on a plat of a quarter acre indicated a yield of about 12 tons per acre. Samples of each variety were analyzed and the results of these analyses are given in Tables VI and VII.

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[a] The work with sugar beets was conducted in cooperation with Dr. C. O. Townsend, of the Bureau of Plant Industry.

Table VI.—*Results of analyses of sugar beets grown on the Truckee-Carson Experiment Farm, 1907.*[a]

Variety.	Source of seed.	Weight after topping.	Sugar in juice.	Purity.
		Ounces.	*Per cent.*	*Per cent.*
"Original" Kleinwanzleben		13	20.40	82.90
"Old Type" Kleinwanzleben		11	21.60	84.20
"Pioneer" Kleinwanzleben		15	23.40	87.00
Kleinwanzleben	Washington State	19	18.70	80.26
Kleinwanzleben, No. 17509		16	22.70	87.30
"Original" Kleinwanzleben, No. 17968		12	19.80	88.80
Schreiber's Special, No. 17969		10	20.80	90.85
No. 17979	Dippe Bros.	16	19.00	85.95
Kleinwanzleben, No. 17972		16	19.00	89.20
Kleinwanzleben, No. 17973	Lehi, Utah	18	22.10	87.70
Kleinwanzleben, No. 17974	Sugar City, Idaho	15	21.70	89.30
Kleinwanzleben, No. 17975	Herning & Co., Germany	14	22.00	88.00
Kleinwanzleben, No. 17976	Mette & Co., Germany	13	19.40	86.22
Kleinwanzleben, No. 17977	Germany	14	21.00	90.13
Kleinwanzleben, No. 17978	Bohemia	15	22.70	92.66
Kleinwanzleben, No. 17979	Holland	13	([b])	([b])
Kleinwanzleben, No. 17980	Briensted, Germany	12	23.30	88.87
Knaw's Mangold, No. 18235		12	22.60	86.69
Knaw's Mangold, No. 18835		13	23.70	86.68

[a] Analyses made by the Bureau of Chemistry, U. S. Department of Agriculture.

[b] Juice lost.

It will be noted that of the nineteen varieties tested thirteen have 20 per cent or more of sugar in the juice.

Table VII.—*Results of analyses of sugar beets grown on the Truckee-Carson Experiment Farm, 1908.*[a]

Variety.	Source of seed.	Soil type.	Weight after topping.	Sugar in juice.	Purity.
			Ounces.	*Per cent.*	*Per cent.*
Kleinwanzleben, No. 21839	Lehi, Utah	Clay	21	16.7	85.2
		Sandy	9	21.1	91.7
Kleinwanzleben Bremstedts, No. 21840.	Harz, Germany	Clay	21	18.7	90.3
		Sandy	5	19.2	89.8
Kleinwanzleben Mette, No. 21841.	Quedlingburg, Germany	Clay	19	17.2	86.8
		Sandy	11	20.3	88.3
Zuckerreichet, No. 21842	Prague, Bohemia	Clay	16	18.3	87.8
		Sandy	11	20.7	91.6
Aderstedts, No. 21843	Magdeburg, Germany	Clay	19	20.8	86.6
		Sandy	16	18.9	89.9
Kleinwanzleben Braune, No. 21844.	Brendorf, Germany	Clay	18	18.1	86.2
		Sandy	16	17.0	82.5
Kleinwanzleben Heine, No. 21845.	Hadmersleben, Germany	Clay	24	17.6	85.4
		Sandy	16	20.2	89.0
Kleinwanzleben, No. 21846	Fairfield, Wash	Clay	24	16.6	84.6
		Sandy	24	19.5	89.2
Kleinwanzleben, No. 21847	do	Clay	24	19.4	92.4
		Sandy	6	20.6	93.2
"Old Type," No. 21848	Klein Wanzleben, Germany.	Clay	28	18.8	87.0
		Sandy	11	20.2	89.8
Kleinwanzleben Strandes, No. 21849.	Anhalt, Germany	Clay	24	16.9	86.6
		Sandy	11	19.3	88.9
Kuhn Kleinwanzleben, No. 21850.	Naarden, Holland	Clay	28	18.6	86.9
		Sandy	19	19.0	85.2
Behren Kleinwanzleben, No. 21851.	Magdeburg, Germany	Clay	28	17.6	88.0
		Sandy	5	21.0	90.9
Horning Kleinwanzleben, No. 21852.	Eisenleben, Germany	Clay	24	17.8	85.5
		Sandy	5	20.1	90.5
Jaensch, No. 21853	Ascherleben, Germany	Clay	28	17.5	88.8
		Sandy	11	20.7	90.3
"Original" Kleinwanzleben, No. 21854.	Klein Wanzleben, Germany.	Clay	24	20.0	89.5
		Sandy	11	20.1	91.3
Schreiber's Specialitate, No. 21855.	Nordhausen, Germany	Clay	28	18.6	92.5
		Sandy	11	20.7	95.8
"Pioneer" Kleinwanzleben, No. 21856.	Klein Wanzleben, Germany.	Clay	24	18.2	89.2
		Sandy	5	20.5	87.5
Wohanka Kleinwanzleben, No. 21857.	Prague, Bohemia	Clay	24	16.8	83.7
		Sandy	4	20.3	91.8
Dippe's Elite Kleinwanzleben, No. 21858.	C. O. Townsend	Clay	20	18.4	92.0
		Sandy	5	19.9	....
Kleinwanzleben, Idaho, No. 21859.	Sugar City, Idado	Clay	24	19.2	87.6
		Sandy	6	19.5	91.8

[a] Analyses made by the Bureau of Chemistry, U. S. Department of Agriculture.

HORTICULTURAL EXPERIMENTS.

No experiments with horticultural or fruit crops were undertaken in 1907. In the spring of 1908 a number of varieties of orchard fruits and small fruits were sent to the farm by Prof. P. Beveridge Kennedy, of the Nevada Agricultural Experiment Station.

POTATOES.

The work with truck crops was begun in the spring of 1908, and in addition to the fruits just mentioned five varieties of potatoes were planted, the seed being furnished by Prof. L. C. Corbett, of the Bureau of Plant Industry.

The varieties under trial were Rural New Yorker, Delmany Challenge, Peachblow, and two unnamed varieties, Nos. 475 and 476. The potatoes were irrigated every ten days. Of the varieties mentioned Delmany Challenge and Rural New Yorker yielded larger crops of marketable potatoes than did the other varieties. Owing to the lack of uniformity in stand and to the fact that these potatoes were not grown under comparable conditions, no estimate can be given of the yields per acre.

Seeds of a number of varieties of vegetables, also furnished by Professor Kennedy, were planted, but the land used was but newly leveled, and the many irregularities in the plats made it impossible to judge of the relative merits of the varieties.

Wherever possible, potatoes should be planted following alfalfa, This practice is followed in the vicinity of Greeley, Colo., where excellent results are secured. The present indications are that potatoes planted on new land will not yield so well nor will the appearance and quality be so good as where they are planted after alfalfa, or even on old land after grain. In the Greeley region a five-year rotation is used with conspicuous success, consisting of three years of alfalfa, followed by potatoes, followed by grain with which alfalfa is seeded.

Potatoes will probably be a most important truck crop for new settlers. The quality of potatoes produced on the project is usually very good, but much influenced by the treatment given. This makes it important that each farmer give the matter of irrigation and cultivation careful study, since not only the yields but the quality of the crops are very markedly influenced by this treatment.

CORN.

In 1907 a number of varieties of corn were planted on the clay lands of series 1 and 2. A few of these varieties matured, but none made good growth or yielded well. It is apparent that corn can not be profitably grown on this heavy soil while it is new and before a considerable amount of organic matter has been put into it.

In 1907 seventeen varieties of corn were planted on the sandy land of the farm, the seed being furnished by Mr. C. P. Hartley,[a] of the Bureau of Plant Industry. These varieties were planted May 11. Several severe frosts occurred after this date, and the growth was very slow during May and early June. The stand, however, was fairly good, and after June 15 the growth was rapid. The plants appeared healthy and vigorous. All of the varieties eared well, and at the time of the first killing frost (September 26) all but three or four of the latest ones had matured.

Considerable injury was inflicted on these corn varieties by blackbirds, so that comparative yields could not be secured. Had the experimental field been larger, or had there been a considerable quantity of corn in the neighborhood, this injury would have been, of course, materially reduced. The indications are that a considerable number of rather early maturing varieties, such as Leaming, Iowa Silver Mine, and the earlier strains of Reid's Yellow Dent, will give good results. While larger yields may be obtained in some years from the heavy-yielding, late-maturing varieties the danger of early frosts is sufficiently great to make it desirable to use only the early-maturing varieties at present. There is apparently nothing to be gained by planting corn before May 15 or 20, as the early corn is often severely checked by the cold weather in late May and early June.

As has been suggested for potatoes, the best results with corn may be expected where the crop follows alfalfa. In fact, such crops as sugar beets, potatoes, and corn should invariably be planted on old alfalfa land, and wherever possible this alfalfa land should be given a top-dressing of manure in the winter or early spring, plowed in April, and put into the best possible tilth before the crops are planted.

ALFALFA EXPERIMENTS.

In addition to field experiments where alfalfa is used both as a forage crop and to improve the soil, experiments with this crop plant are being carried on under the direction of Mr. C. J. Brand, of the Bureau of Plant Industry, in which thirty-two strains and varieties of alfalfa gathered from as many different sources, both in this country and abroad, are being studied.

Three different methods of planting were used with each variety. Plats 1 rod by 2 rods were planted in drill rows 6 to 8 inches apart. Single rows of each variety were planted, the rows being 36 inches apart to permit intertillage. Also seed of each was planted in hills 36 inches apart each way, and later thinned to one plant in each hill.

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[a] The field work was done under the direction of Mr. L. L. Zook, who has contributed the report which follows.

It is the aim to observe the relative behavior of these strains planted in these different ways in order to note the reactions of each to the different conditions presented, and from these studies to learn the causes of the success or failure of each.

TREE PLANTINGS.

In the spring of 1908 about 5 acres of the sandy land of the experiment farm was planted to trees in cooperation with the Forest Service. These trees were one and two year old seedlings from a nursery in Nebraska and included cottonwood, honey locust, black locust, willow, and Russian olive. The trees were set 6 feet apart each way, irrigated by flooding, and cultivated from time to time. Late in the season the rabbits caused considerable damage by girdling some of the trees. This was effectually checked by painting the trees with white lead. The cottonwoods and honey locusts did the best in the field planting, while the Russian olive, which was set along the ditch banks, made very rapid growth. Tamarisk cuttings, obtained locally, were set along some plat borders and made a growth of 6 to 8 feet the first season.

EXPERIMENTS ON ALKALI LAND.[a]

Alkali occurs in various parts of the Truckee-Carson Project, especially in low places where the ground water is near the surface of the soil and where the drainage from surrounding higher ground has accumulated by seepage. The greater part of the alkali is found in the heavier soils, but some of the light sandy soil is also more or less salty.

As a rule it will be possible to get rid of the alkali by drainage and heavy flooding. This will be comparatively easy to accomplish in the lighter soils, provided the ground water table can be kept down. In the heavier soils, however, the physical condition of the soil is a serious obstacle to its reclamation on account of the puddling effect of the alkali salts, making the penetration of water difficult.[b]

The addition of organic matter is one of the most effective means of improving the physical condition of heavy alkali soils. This can be done by disking in coarse farm manure or by growing and plowing under a green crop, using some specially alkali-resistant species.

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[a] The chapter describing the alkali conditions and the experiments with crops for alkali land has been prepared by Mr. T. H. Kearney.

[b] Certain types of alkali, unless present in excessive amounts, probably cause as much damage indirectly by their effect upon the physical condition of the soil as by their direct physiological action upon the plants. Not only do the alkali salts, when present in heavy soils, hinder the penetration of water, but they help to form a hard crust on the surface, which seedling plants find difficulty in breaking through.

Under ordinary conditions the growing of resistant crop plants is not to be recommended as a final solution of the alkali problem, but they will often aid in preparing the way for more valuable crops. In places where the local conditions will not permit reclamation by drainage, or where the cost of drains is for any reason prohibitive, it may be necessary to continue growing resistant crops. Seeding such land, especially if the water table is near the surface, to some of the perennial meadow and pasture grasses which will stand considerable alkali, is probably the best solution of the problem which can be offered at present.

CHEMICAL COMPOSITION OF THE ALKALI.

The alkali found on the project is a less harmful type than that which occurs in many localities,[a] the predominating salt being sodium sulphate with sodium chlorid and sodium bicarbonate occurring as secondary components. Alkali of this type is generally less harmful to plant growth than that in which sodium chlorid is the principal salt. Black alkali (sodium carbonate) occurs in places on the project, although usually forming only a very small percentage of the total salts. Where this salt is present in such quantity as to amount to one-twentieth of 1 per cent of the dry weight of the soil, it becomes a serious menace to plant growth, through its corrosive action on the plant tissues. Sodium carbonate, more than any other salt, tends to puddle the surface of the soil and prevent leaching under irrigation. In places where an excess of this salt occurs, treatment with land plaster (calcium sulphate) may be necessary in order to neutralize the free alkali.

Where sodium carbonate is absent, or present only in small quantities, a considerable variety of crop plants can be grown with proper management in the presence of an average of one-half of 1 per cent of alkali in the first 3 feet of soil. The chief precautions necessary are to wash the alkali down out of the upper few inches of the soil at the time of seeding and to prevent the soil becoming very dry at any time during the growing season.[a]

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[a] Experiments in the greenhouse with a considerable number of different grasses and leguminous forage plants grown in alkali soil from Fallon and from other localities in the West, showed the Fallon alkali to be less harmful with the same percentage of salts to dry weight of soil and the same concentration of soil solution than the one in which the bulk of the alkali was sodium chlorid. Where only 0.2 per cent total salts to dry weight of soil was present, and the percentage of soil moisture was about the optimum for plant growth in the type of soil used, the Fallon alkali had an actually stimulating effect on the germination of grasses.

RESISTANT CROP PLANTS.

As a result of the experiments in 1907 and 1908, it was found that a number of species are decidedly more resistant to alkali than others. One of the most resistant crop plants is the sugar beet, and some of the cereals are also able to make a limited growth and even ripen a small amount of seed in the presence of as much as 1 per cent of alkali. But in both of these classes of crops the value of the product is injured by an excessive amount of alkali. In the case of the sugar beet, the purity coefficient is seriously impaired, even though roots of good size are formed. The seed ripened by the cereals in strong alkali soils is generally small and shrunken, and hence of little value.

On the other hand, with forage plants it is only necessary to get a good development of leaf and stem to make them valuable. If this is accomplished they may serve for pasturage and hay, and also as green-manure crops, which can be plowed under and thus greatly improve the physical texture of alkali soils. Often the improvement of texture thus brought about by making the soil more permeable to water insures its being easily reclaimed by washing out the excess of salts.

Among the forage plants found to make a good growth in the presence of large amounts of alkali, some of the grasses take the first rank. Western wheat-grass (*Agropyron occidentale*), tall meadow oat-grass (*Arrhenatherum elatius*), smooth brome-grass (*Bromus inermis*), tall meadow fescue (*Festuca elatior*), and Italian rye-grass (*Lolium italicum*) were found to be especially tolerant of alkali. With proper management a good stand of any of these grasses can probably be secured in the presence of from one-half of 1 per cent to 1 per cent of total salts in the first 3 feet of the soil, in case there is no considerable amount of black alkali present. Italian rye-grass seems to be especially promising as a rapid-growing lawn and pasture grass for alkali soil. Unfortunately, it is a short-lived grass and will have to be reseeded every year or two.

Other grasses that are probably less resistant than the preceding, yet should do well in the presence of nearly or quite one-half of 1 per cent of total salts, are slender wheat-grass (*Agropyron tenerum*), redtop (*Agrostis alba*), orchard grass (*Dactylis glomerata*), and perennial rye-grass (*Lolium perenne*). In fact, it would appear that most of the standard meadow and pasture grasses are more or less alkali resistant.

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[a] The harmfulness of a given percentage of salts to dry weight of soil of course depends largely on the amount of moisture present, which determines the concentration of the soil solution. One-half of 1 per cent of salts may be practically harmless to a given species in a moist, but fatal in a dry, soil.

The German or Hungarian millet proved to be decidedly alkali resistant, and was found to make a practically normal growth and to head out where there was one-half of 1 per cent of alkali in the first foot of the soil, and 1 per cent in the second.

Considerable tolerance for alkali was shown by some of the sorgos and milos. Dwarf milo was able to make about one-half of its normal growth and to mature small heads in the presence of very nearly 1 per cent of total salts in the first 3 feet of the soil. Amber sorgo made a corresponding growth and headed out in places where the alkali content of the first 3 feet of the soil amounted to one-half of 1 per cent.

The leguminous forage plants are much less resistant than the grasses. The best results were obtained with sweet clover (*Melilotus alba*). This plant made a good growth where there was three-tenths of 1 per cent of alkali in the first foot of soil, and 1 per cent in the second foot, about three months after seeding. A smaller but still healthy growth was made in the presence of seven-tenths of 1 per cent in the first foot, 2½ per cent in the second, and more than 3 per cent in the third foot. Two-year-old plants, 4 feet high, were found to be ripening seed where there was nearly three-tenths of 1 per cent of alkali in the first 3 feet of the soil, with considerable black alkali present.

Canada field peas and horse beans (*Vicia faba*) were found to be fairly resistant to alkali in the young stage of growth, but neither of these species seems to be able to stand the hot summers at Fallon. The plants rapidly dried up after the first of July. The hairy vetch (*Vicia villosa*) can endure the presence of one-half of 1 per cent of salts in the first 3 feet of soil, but remains in a dwarfed state under these conditions. Where the alkali does not exceed 0.2 or 0.3 per cent this vetch will probably be found to be one of the most successful leguminous forage plants.

Among the most alkali-resistant plants tested were Essex rape and thousand-headed kale. A good stand and fair growth of both these species can be secured in the presence of nearly or quite 1 per cent of total salts in the first 2 or 3 feet of the soil.

Certain native grasses of the project, notably slender water grass (*Leptochloa fascicularis*) and barnyard grass, the seeds of which are widely distributed with the irrigation water, are able to stand a considerable amount of alkali, and are of some value for wild-grass hay and pasturage.

CROP PLANTS RECOMMENDED.

Wherever conditions make it feasible, it is desirable to reclaim alkali land by washing out the salts rather than to rely upon resistant crop plants for its utilization. During the process of reclamation, however, it is preferable to grow something on the land rather than to leave it fallow, especially as the addition of organic matter to such land improves its texture, and thus not only facilitates washing out the salts, but makes the conditions more favorable for seeding to less resistant crops after reclamation is completed. German millet, rape, kale, and sweet clover are the most promising green-manure crops for alkali soils. Resistant crops that can be intertilled, and thus also aid in reclamation, are sugar beets, kafir, milo, and the cane sorghums. If for any reason reclamation by flooding and drainage is impracticable, it will probably be most advantageous to seed the land to some of the perennial grasses mentioned, either singly or in mixture.

INDICATOR PLANTS.

In selecting land for farming in irrigated districts it is very important to ascertain whether there is any considerable amount of alkali present, either near the surface or at lower depths in the soil. In the latter case there is always danger that the application of irrigating water for a number of years and the consequent raising of the water table will bring the salts to the surface.

The best indicator of the presence of alkali in the virgin land is the character of the native growth upon it. Where such comparatively short-rooted species as salt-grass (*Distichlis spicata*), blueweed (*Heliotropium curassavicum*), mintweed (*Iva axillaris*), and saltwort (species of Suæda) occur, the surface soil is usually moist and the alkali salts are already accumulated there. It then becomes a question of determining the amount of salts present and the possibility of getting rid of them by drainage. The presence of certain larger, deeper rooted species, even though associated with small, shallow-rooted plants that do not indicate the presence of alkali, is a warning that considerable amounts of soluble salts occur at greater depths in the soil, and the possibility must always be borne in mind that this alkali is likely subsequently to come to the surface, preventing the growth of crops. Native plants in the latter category are the larger saltbushes (species of Atriplex), rabbit brush (species of Chrysothamnus), and greasewood (*Sarcobatus vermicularis* and *S. baileyi*). The presence of greasewood is an almost certain indication that alkali occurs somewhere within reach of its roots.

SUMMARY.

The Truckee-Carson Irrigation Project lies near the western edge of the Lahontan basin, in western Nevada. The water supply is drawn from the combined flow of the Truckee and Carson rivers.

The climate is one of moderate temperatures, low rainfall with low atmospheric humidity, and few cloudy days.

The good railroad facilities and the mining camps in adjacent hills provide an outlet to good markets for the agricultural products.

There are three important classes of soils on the project, the river and lake bottom lands, which contain an abundance of organic matter and are immediately fertile where the alkali is not injurious, the sandy desert soil, and the clay desert soil. The desert soils are deficient in organic matter. The sandy soils are easy to work, but are likely to be blown about by the occasional windstorms. The clay soils are at first difficult to work, but once put in good condition by the addition of organic matter they bid fair to be very valuable.

There has been some agriculture on the project along the Carson River for half a century. The present agricultural development, however, dates from 1905, when the present irrigation works were completed.

The earlier agriculture of the project was centered around livestock production, and present indications are that some form of stock farming must have a large place in the future agricultural development. Heavy truck crops, fruits enough for local needs, and sugar beets are promising as subsidiary lines.

The Truckee-Carson Experiment Farm, located 1 mile south of Fallon, Nev., is operated by the United States Department of Agriculture in cooperation with the Nevada Agricultural Experiment Station and the United States Reclamation Service. The farm includes 160 acres, of which about 40 acres are now under crop.

The experimental work is for the most part conducted under the direction of experts and specialists in the Department of Agriculture and the Nevada State station.

Experiments in subduing the clay land show that it should not be plowed deep at first, and that special farm implements and careful irrigation are necessary to get crops started.

The sandy soils show the need of great care in preventing the exposure of new land to the action of wind during the spring.

Experiments with forage and green-manure crops show that redtop, rape, and sweet clover are best adapted to the heavy soils, when first broken.

Two years' experiments with sugar beets show that good crops of beets of a high sugar content may be expected.

Potatoes of excellent quality can be produced, and good crops of corn are possible. Either winter or spring wheat may be grown, and oats and barley yield well.

Alfalfa, the most important crop of the region, yields two or three cuttings each year, besides improving the land for other crops.

The region is nearly timberless, and extensive tree plantings should be undertaken, not only to provide wind-breaks, but also for fuel. The cottonwood and the honey locust do well, while the tamarisk makes quick growth along ditch banks and field borders.

Experiments with alkali land to find the plants most resistant to alkali show that such crops as sugar beets, sorghum, and some grasses may be grown on such land with proper care in tillage and irrigation.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 158.

B. T. GALLOWAY, *Chief of Bureau.*

THE ROOT-ROT OF TOBACCO CAUSED BY THIELAVIA BASICOLA.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 5, 1909.

Sir: I have the honor to transmit herewith and recommend for publication as Bulletin No. 158 of the series of this Bureau the accompanying paper, entitled "The Root-Rot of Tobacco Caused by Thielavia Basicola," by Mr. W. W. Gilbert. This paper has been submitted with a view to publication by Mr. W. A. Orton, Pathologist in Charge of Cotton and Truck Disease Investigations.

Within the last few years this disease has become increasingly injurious to tobacco, particularly in the Connecticut Valley, where tobacco is the principal money crop. A study of the fungus causing the disease has been made, and the methods of seed-bed sterilization herein described provide a means of controlling it in the seed beds.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE ROOT-ROT OF TOBACCO CAUSED BY THIELAVIA BASICOLA.

INTRODUCTION.

During the last few years a root-rot of tobacco has caused considerable loss to growers in certain sections of the United States, and the disease has become so prevalent that it must be reckoned with and some means of checking its ravages adopted in order to cultivate the crop successfully. Fortunately the area over which the disease is severe, so far as our present knowledge goes, is not very large, being confined to Connecticut, but the loss in individual cases is nevertheless great. Many instances are known where the entire crop of seedlings raised by a farmer had to be discarded because of the root-rot and healthy plants purchased to take their place, thus entailing not only the loss of his total outlay of work and fertilizers, but in addition the extra expense of buying healthy plants.

In some communities where the trouble has been general there has been considerable difficulty in securing healthy plants, with the result that the excessive demand caused an advance in price, making the actual loss much greater. Before the effects of the disease were more generally understood, additional loss was caused by the setting of diseased plants in the fields. Even though the conditions were the very best for the plants, some were not able to get a foothold and had to be reset, while in many cases the entire crop, after remaining two or three weeks at a standstill with occasional plants dying, has been plowed up and the land reset with plants from other sources. These operations involve a great deal of labor that is absolutely wasted, to say nothing of the time lost to the crop. No small amount of loss has also been occasioned by the fact that healthy plants, when set, have been attacked and the crop so stunted that 75 to 100 per cent has been rendered unmarketable.

DESCRIPTION OF ROOT-ROT.

The root-rot of tobacco is characterized by the blackening and decay of the taproot and lateral roots of seedlings and of larger plants in the field, caused by the growth in their tissues of the fungus

Thielavia basicola Zopf. The macroscopic effects of the disease upon the plants attacked vary considerably with the conditions under which they are grown, but an unhealthy appearance of the leaves is almost always to be noted.

THE DISEASE IN THE SEED BED.

Damping-off.—If attacked while very young, the seedlings are sometimes killed when not more than one-third to one-half inch high, in much the same manner as by "damping-off" fungi except that the fungous hyphæ penetrate not only the portion of the plantlet near the soil line, but also the rootlets and the stem above, spores having been seen protruding from the stem of a seedling all the way from the soil to the cotyledons, as well as on the rootlets.

Effect on roots.—In other cases, when conditions do not favor as severe an attack, the roots alone are directly invaded by the fungus and the plants are stunted. If one of the slightly diseased plantlets is very carefully taken up and the adhering soil washed away, it will be noted upon examination that the tips of a number of the rootlets present a brown or black appearance, according to the length of time the fungus has been working. The browning of the tissues is caused by the disintegration of the root by the fungus living in it parasitically and the black color by the subsequent production of spores. The disease progresses up the roots, both taproot and laterals being attacked, until the entire root system is destroyed, and if such a plant is pulled all the roots break off and remain in the soil, the blackened base of the stem alone showing where the roots were attached. The end of the taproot is most commonly attacked first and then the laterals. (Pl. III, fig. 3, *B*.)

As the root system thus becomes reduced, the plantlet usually puts out numerous lateral roots to take the place of those rendered useless by the disease. These serve to nourish the plantlet for a time, but eventually become diseased and decay.

Effect on leaves.—The appearance of the leaves of diseased seedlings varies with the soil and with the plant food available. When the beds are made of rich soil, heavily fertilized with quickly available materials, such as hen manure or sodium nitrate, the plants may present a very vigorous appearance, though the leaves are usually of a darker green than is customary with perfectly healthy plants. However, such plants exhibit root systems very badly diseased, not infrequently the taproot breaking off just below the surface of the soil; this has been noted even with plants 4 to 6 inches tall.

In other cases, where the soil is poor and little quickly available fertilizer has been used, the plantlets are distinctly stunted and the leaves have a sickly yellow color, which appears first at the tips, but gradually pervades the whole leaf. Few, if any, new feeding roots are produced, and the plant makes little appreciable growth. The beds present a very uneven appearance, the plants being large in some spots and in others small and scattered.

In any case the result is the same; the plants are rendered unfit for setting and the beds are a total loss, the farmer being obliged to purchase healthy plants when his own beds should have produced more than enough plants to set his fields.

THE DISEASE IN THE FIELD.

When badly diseased plants are set in the field they generally remain for two or three weeks without any apparent growth, some yellowing, wilting, and dying during that period. Finally a large portion of a field set with diseased plants has to be reset. If the soil is of a light, open texture the survivors may eventually gain the ascendency over the disease and under favorable circumstances produce a fairly good, though late, crop, but in the heavier soils the disease persists, and the tobacco, though making some growth, is permanently crippled and produces few, if any, marketable plants. Cases have been observed where diseased plants have reached maturity at a height of 8 to 15 inches, the root systems being a mass of decayed rootlets, all breaking off to within a few inches of the base of the stem when the plants were pulled. (Pl. III, fig. 2.)

In the spring of 1906 three cases came to the attention of the writer in which fields of from 1 to 4 or 5 acres were set with diseased plants, and after ten days or two weeks plowed up and reset, because the plants were so badly affected that they made no growth whatever and gave no promise of it. In one case, in a field of several acres, the majority of the plants were so badly diseased and stunted that the crop was not worth harvesting. More generally, however, the trouble is worse in spots over the field. (Pl. V, fig. 1.) It matters little whether diseased plants are set in a field where no infection is present or whether healthy plants are set in a field already diseased; the result is the same, and where the conditions are favorable for the development of the disease the crop is seriously injured.

When large roots are attacked by the fungus, the tissues, being older and tougher, are not as easily penetrated as those of smaller roots, and the growth, except in very severe cases, is generally confined to the outer surface, where a brownish, scurfy appearance is to be noted, and sometimes an enlargement of the root at the point attacked.

Where whole fields become infected in the manner described, the problem becomes complicated, since methods that might be practical in the treatment of restricted areas used for seed beds would be far too costly for use in large fields.

DESCRIPTION OF THE FUNGUS CAUSING ROOT-ROT.

Thielavia basicola, the fungus which causes the root-rot of tobacco, belongs to the ascomycetous family Perisporiaceæ. It is characterized by the production of three kinds of spores, known, respectively, in the order of their appearance, as endoconidia, chlamydospores, and ascospores.

MYCELIUM.

The mycelium consists of much branched hyphæ, generally much septate, but sometimes sparingly so, hyaline at first, but later becoming slightly brown. The fungous threads are very small, the diameter of the cells varying in culture from 3 to 7 microns. Moreover, some hyphæ are strictly linear, while others are very irregular in outline. When young the cells of the mycelium are filled with granular protoplasm, but in old cultures the protoplasm is less abundant.

The manner of branching is quite characteristic in that it is in many cases almost dichotomous, the branch being thrown out from the apex of a cell of the main hypha, where a slight enlargement takes place and a cell wall develops, cutting off the branch from the main hypha.

ENDOCONIDIOPHORES.

Arising from the mycelium at various points, sometimes singly, sometimes in clusters, are hyaline to dingy brown thin-walled branches, which form endoconidiophores of a few to several short, plump, barrel-shaped cells, terminated by a long tapering cell within which the endoconidia are produced. Zopf has given these endoconidiophores the characteristic name "pistolenförmige Conidien-bildungen," pistol-shaped conidial formations. (Pl. I, figs. 4 and 5.)

ENDOCONIDIAL CELL.

The terminal or endoconidial cell is slightly swollen at the base and gradually tapers to the long, almost linear delivery tube through which the conidia are discharged. In length the cells vary from 90 to 170 μ, with a basal diameter of 5 to 6 μ, and they are 3 to 5 μ in diameter at the mouth of the delivery tube. (Pl. I, fig. 4.)

The endoconidia are produced from the copious protoplasm within the terminal cell, which opens by a bursting or dissolution of the tip, and the conidia are slowly pushed out by the growth of the protoplasm in the swollen basal portion of the cell, new conidia being formed continuously in the rear of those being ejected. It is sometimes difficult to perceive that the conidia originate within the terminal cell and are not formed by its direct septation, as the walls of the conidia and of the delivery tube are so thin and transparent and fit so closely together that a high power is necessary to discern this point. Quite frequently, however, a conidium will be found projecting part way out of the delivery tube, or, again, in old cultures the last conidium may have been knocked out, leaving the end of the delivery tube empty, so that the fringed or notched orifice is visible. In young cultures the conidia are produced in great numbers, giving a silvery white appearance, the conidia being pushed out in long lines or, in case the conidiophore is erect, falling in little piles. Aderhold has counted 160 conidia which came from a single endoconidial cell, and the writer has seen 40 in drop cultures twenty-four hours old.

ENDOCONIDIA.

When young the endoconidia are hyaline, thin walled, linear, and very slightly rounded at the ends. When about to germinate they swell and assume an ovoid shape. The contents of the conidia are very transparent, with a large vacuole in each end. In old cultures conidia have been observed of a slightly brownish color and with thickened cell walls. Conidia vary from 8 to 23 μ in length by 3 to 5 μ in diameter, the average being about 15 by 4 μ. This fructification is the most characteristic of Thielavia, since such a conidial formation is of very infrequent occurrence. (Pl. I, fig. 1.)

In corn-meal cultures conidia are produced in profusion in two to three days, and they doubtless serve as the most prolific means of dissemination of the disease, as they may germinate at once, while the chlamydospores and ascospores produced later require at least a short period of rest before being able to start new growth.

CHLAMYDOSPORES.

The chlamydospores, second in order of production, are often borne on the same hypha as the endoconidiophores, on short lateral branches put out from just below them; or they may be produced from any portion of the mycelium. They are sometimes borne singly, but more often in many-branching clusters. These spores are much thicker walled than the conidia and are more richly supplied with protoplasm and reserve food material in the form of oil globules, and thus are adapted to serve as resting spores. In color they vary from a brownish black to an olive-brown, in mass usually giving a dull black color. Most writers have considered them as single spores borne in chains of three to six, but they are more properly treated as compound spores made up of two to three basal cells surmounted by one to eight fertile segments. The basal cells are thin walled, hyaline, and sterile, while the fertile cells are dark brown and surrounded by thick walls, and eventually separate into short cylindrical individual cells, each one of which is capable of germination.

The compound spores are club shaped, usually tapering slightly from the rounded terminal cell to the first sterile basal cell, and then more abruptly to the hypha, on which they are borne. In length the chlamydospores vary from 25 to 65 μ, the majority being about 45 μ, with a diameter of 10 to 12 μ, the individual segment measuring from 5 to 18 μ in length. There are slight constrictions at the points of division between the segments, the cross walls being almost invariably perpendicular to the long axis of the compound spore. The exterior of the spores is slightly roughened. Many forms of branching are found. Sometimes a main hypha bears spores singly on all sides at close intervals; in other cases they are borne in close, broomlike clusters, several spores emanating from one place, or one spore from a sterile segment at the base of another, a third from the base of this, and so on until a dense bunch of spores results. In some instances one, two, or three spores have been observed to originate from another compound spore. (Pl. I, figs. 5 and 6.)

ASCOSPORES.

The ascosporic stage, the last to develop, is found abundantly on old diseased roots of tobacco, but the writer has never succeeded in getting it in pure cultures. Peglion (37) [a] alone, of all who have studied the fungus in culture, reports having obtained it on old potato cultures to which was added sterilized water acidulated with 0.6 per cent of tartaric acid and the tubes kept in the thermostat at 25° C. for a week.

The perithecia are borne in the midst of the other spore forms. The writer was fortunate enough to observe a perithecium attached to the same hypha which bore an endoconidiophore. The perithecia are round, dark brown, rough, and thick walled, and without any aperture for the escape of the ascospores. (Pl. I, fig. 8.) In diameter the perithecia vary from 80 to 100 μ, and within them are produced a number of fragile, egg-shaped asci, in each of which are developed eight oblong, nonseptate, slightly spindle-shaped spores, of a chocolate-brown color when ripe, thick walled, and provided with a large central oil drop. (Pl. I, fig. 9.) The spores measure 8 to 10 μ by 4 to 5 μ and are set free within the perithecium by the deliquescence of the asci walls before the spores are ripe. It is therefore exceedingly difficult to observe the asci. The ascospores are released by the disintegration or rupture of the perithecium, which takes place soon after the ripening of the spores; consequently, spores are rarely found in the perithecium on old diseased roots, but free. These spores have never been observed to germinate by the writer. Although hundreds of examinations of both fresh material and microtome sections cut for the purpose have been made by the writer, thus far no asci have been found. They are, however, figured by Zopf (58), and the writer has no reason to question their existence.

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[a] The numbers in parentheses refer to the bibliography at the end of the bulletin.

MEANS OF DISSEMINATION.

From the observations of Sorauer (48) it would seem probable that Thielavia is rather widely distributed in soils of abundant humus content, and particularly in leaf mold. This is borne out by the fact of its known occurrence in at least seven countries of the world. Its introduction into tobacco seed beds may occur in a number of ways. Leaf mold is sometimes used in the preparation of the beds, and the fungus may thus be brought in. Infected soil clinging to the feet of men or animals or to tools and the custom of buying seedlings for setting which may have the disease so slightly as not to be noticed are probably common agencies in the transmission of the trouble from one seed bed to another. Instances have come to the writer's notice where a single spot in a seed bed showed the disease one year, but by the next the entire bed and others adjacent had become infected, the spores having been scattered when the beds were prepared and through watering and subsequent cultivation and weeding.

PARASITISM OF THE FUNGUS.

Investigators of Thielavia almost without exception have acknowledged its parasitic nature to a degree, some, however, believing it to be a very weak parasite very largely dependent on conditions, and a few being in doubt as to its true nature.

CONCLUSIONS OF VARIOUS WRITERS.

It was Berkeley's (5) opinion that the fungus "was either destructive of the plant on which it grew or was developed on it in consequence of previous disease."

Zopf (59) characterized it as an undoubted parasite attacking the root systems of a number of plants, causing serious injury, and in some cases even their death.

Sorauer (48) concluded from his study of Thielavia causing the root-brown of cyclamens, that, though it was quite generally to be found living saprophitically in soil rich in humus, it could not always attack plants, but only when they were especially susceptible from some other reason, such as excessive manuring, too abundant watering, or too high temperature.

Peglion (33), while recognizing the parasitic as well as the saprophytic mode of life of the fungus, stated that the extensive injuries to young tobacco plants might probably be attributed in part to improper cultural conditions, especially excessive watering, the presence of too much humus, and the too close proximity of the roots to the manure used for making the hotbeds. The tender rootlets being thereby injured were readily attacked by the fungus.

Selby (43), Benincasa (3), and Campbell (11) all considered the fungus an active parasite of tobacco, while Aderhold (1) concluded from his inoculation experiments with several plants not reckoned among its hosts that it was not vigorously parasitic and caused much injury only under certain conditions. Galloway (25) likewise held that it was only a weak parasite on violet stems and roots, and that loss could be avoided by the exercise of special care in the selection of soil and in transplanting.

Clinton (19), though fully satisfied as to the parasitism of Thielavia in the seed beds, was doubtful whether or not "the very conspicuous trouble in certain of the tobacco fields of Suffield, Conn., was primarily and chiefly due to the attacks of the fungus."

After a detailed study of the fungus in field, laboratory, and greenhouse extending over three years, the writer has no doubt of the parasitism of Thielavia on the tobacco plant in seed bed and field, though the virulence of its attacks, like those of other fungi on their hosts, varies considerably with the conditions of its environment.

DEMONSTRATION OF PARASITISM OF THIELAVIA.

Petri-dish experiments.—To demonstrate the parasitism of Thielavia, the following experiments were carried out: Four large petri dishes were fitted with double layers of white blotting paper moistened with Koch's nutritive solution and sterilized in the autoclave. All were then sown to tobacco, the seed being scattered rather thickly over the surface of the upper layer of blotting paper and the dishes placed in the thermostat at 30° C. for one and one-half days and then transferred to room temperature and placed in the light. After four days, when the seeds were beginning to germinate, two dishes were watered with sterile water which had been thoroughly inoculated with Thielavia, the remaining dishes receiving the same amount of sterile water. A few days later the seedlings in the inoculated plates were beginning to go down in a manner similar to that of plants attacked by damping-off fungi, and at the end of two weeks every plant had been killed. Examination of the plants attacked showed the presence of Thielavia in every instance. The check dishes showed no traces of Thielavia, and the plants remained perfectly healthy until the termination of the experiment. This experiment was repeated several times, and almost identical results were secured in every instance. (Pl. II.)

Pot experiments.—To further demonstrate the parasitism of the fungus under more natural conditions, on November 26, 1906, six 8-inch greenhouse pots were filled with rich soil from a badly diseased Connecticut seed bed and autoclaved one and one-half hours at 117° C. On November 28 all were sown to Connecticut Havana tobacco, and on November 30 one pot was inoculated with Thielavia by mixing a considerable quantity of spores from a pure culture with a beaker of sterile water and watering the pot therewith. On January 2, 1907, a second pot was inoculated in the same manner. On January 12 a number of plants were found damped-off in several of the pots, both inoculated and uninoculated. Upon examination Thielavia was found in the dead plants from inoculated pots, but the trouble in the uninoculated pots was due to some other cause, no Thielavia being present.

On April 4 the experiment was terminated, the plants in all six pots being examined, with the following results:

The plants remaining in the four check pots, uninoculated, were found perfectly healthy, roots clean and white.

The plants in the pot inoculated November 30 were very badly diseased, the majority of the roots being blackened and rotted in some degree; Thielavia abundant.

The plants in the pot inoculated January 2, 1907, were even more severely diseased, the roots of every one being blackened and dead to the stem and in some cases up the stem one-eighth to one-half inch.

The experiment was repeated several times under slightly different conditions with virtually the same results in all cases. (Pl. IV, fig. 3.)

HISTORICAL DATA ON ROOT-ROT.

DISCOVERY OF THIELAVIA ON TOBACCO IN THE UNITED STATES.

It is not definitely known just how long the root-rot has been prevalent in tobacco sections of the United States, but data from farmers warrant the belief that it has been causing loss for at least eight or ten years. The amount of loss has been greater within the last three or four years than ever before because of both the wider distribution and the greater virulence of the disease.

Prof. A. D. Selby (43), of the Ohio Agricultural Experiment Station, was the first to report this disease of tobacco in the United States, specimens of White Burley seedlings affected by the trouble having been sent to him from Neville, Clermont County, Ohio, in the spring of 1899, and the trouble reported again from Germantown in 1903. In Connecticut the root-rot was first brought to public attention by Mr. A. D. Shamel (45), of the Bureau of Plant Industry, in the spring of 1906, a note calling attention to the serious injury caused in the seed beds of the Connecticut Valley being printed in the Hartford Courant for May 28 of that year. Specimens of the diseased plants were sent to the mycologist of the Bureau of Plant Industry, Mrs. F. W. Patterson, and the fungus *Thielavia basicola* causing the trouble was identified by her. About June 1 of the same year the writer was delegated by the Chief of the Bureau of Plant Industry to make a complete study of the trouble with a view to the determination and introduction of some means of reducing or eliminating the loss occasioned. The trouble has since that date been personally located and studied in the seed beds or the fields of 24 tobacco farmers in the Connecticut Valley, with reports of occurrence from numerous other points. and has also been found at one place in Kentucky.

DISCOVERY OF THIELAVIA ON OTHER HOSTS THAN TOBACCO IN THE UNITED STATES.

Thielavia was first reported as a parasite in America by Thaxter (51) in 1891, who found it affecting the roots of violets. Galloway (25) in 1899 studied the trouble on violets and was able to avoid serious loss from its attacks by paying special attention to cultural conditions. About the same date Dr. Erwin F. Smith (46) reports having noted the occurrence of Thielavia in some of his greenhouse experiments, where it attacked cotton and cowpea seedlings, causing rotting of the stems at or beneath the surface of the soil

DISCOVERY OF THIELAVIA ON TOBACCO IN EUROPE.

In Europe root-rot of tobacco was brought to the attention of scientists earlier than in America, as Peglion (33) first reported it in 1897 as prevailing in the seed beds of the tobacco agency at San Sepolcro in north central Italy and stated that the tobacco plant had not up to that time been reckoned among the host plants of Thielavia. Subsequently the trouble was studied and reported from Italy by Benincasa (3), Cappelluti-Altomare (12), Campbell (11), Buttaro (8), Wuiovich (55), and others.

PREVALENCE OF AND INJURY CAUSED BY THIELAVIA IN EUROPE.

Comparatively few definite data have come to the writer's attention relative to the prevalence of and the amount of injury caused by Thielavia in Italy. The trouble has been reported by Peglion from San Sepolcro, in the vicinity of Florence, in north-central Italy; by Buttaro and Benincasa from Pontecorvo, in southwestern Italy, not far from Rome; by Bruni and Barbatelli from Scafati, south of Naples, from several other points in Italy, and from Sardinia.

Peglion gives no note of the distribution of the disease or of the amount of injury caused, but states that the mortality of the seedlings is a constant factor, shown especially in some of the more delicate and exotic varieties. Campbell (11) states that the loss caused by the rot of seedlings in the beds is known to all tobacco growers, forced as they are at times to greatly reduce their planting through lack of young plants to set out.

Benincasa (3) gives very little with regard to prevalence, but notes in 1902 that injury in the seed beds at Pontecorvo, even to the most resistant varieties, had never been as severe as that year, and adds that the disease would have reached the proportions of a disaster had not a remedy been found in the planting of later nurseries and the giving of more space to the plants. The injury in the field reached the highest limits and growth was much retarded. These reports would indicate a rather general distribution of the trouble and no small amount of injury therefrom.

HOSTS AND DISTRIBUTION.

To give some idea of the wide range of its hosts, a list of plants on which Thielavia has been found, together with the locality and authority, is given:

Plants on which Thielavia has been found, with locality and authority.

Name of plant.	Locality.	Authority.
Aralia quinquefolia (ginseng)	Ohio	Selby.
	New York	Whetzel.
Begonia rubra	Ohio	Selby.
Begonia sp	Germany	Zopf.
Catalpa speciosa	Ohio	Selby.
Cochlearia armoracia (horse-radish).	Kazan, Russia	Sorokin.
Cyclamen sp	Germany	Sorauer.
Gossypium herbaceum (cotton)	Washington, D. C.	Smith, E. F.
Lupinus albus	Halle, Germany	Zopf.
Lupinus angustifolius	Halle, Germany	Zopf.
Lupinus luteus	Halle, Germany	Zopf.
Lupinus thermis	Halle, Germany	Zopf.
Linaria canadensis	Connecticut	Gilbert & Stewart.

Plants on which Thielavia has been found, with locality and authority—Continued.

Name of plant.	Locality.	Authority.
Nemophila auriculata	King's Cliffe, England	Berkeley & Broome.
Nicotiana tabacum (tobacco)	Italy	Peglion, Campbell, Buttaro, Wuiovich, Benincasa, Cappelluti-Altomare.
	Sardinia	Gafaro.
	Ohio	Selby.
	Connecticut	Shamel, Clinton, Gilbert.
	Kentucky	Gilbert.
	Cuba	Bessey, E. A.
Nicotiana rustica	(?)	Kirchner.
Onobrychis crista-galli	Halle, Germany	Zopf.
Oxalis corniculata, var. *stricta*	Connecticut	Gilbert & Stewart.
Pisum sativum (pea)	King's Cliffe, England	Berkeley & Broome.
	Halle, Germany	Zopf.
	Gembloux, Belgium	Marchal.
Phaseolus vulgaris	(?)	Kirchner.
Phaseolus multiflorus	(?)	Kirchner.
Senecio elegans	Berlin, Germany	Zopf.
Trigonella coerulea	Halle, Germany	Zopf.
Vigna sinensis (cowpea)	Washington, D. C	Smith, E. F.
Viola odorata	Connecticut	Thaxter.
	Takoma Park, Md	Galloway.
	Washington, D. C	Smith, E. F.
Trifolium repens (white clover)	Connecticut	Gilbert & Stewart.

In addition to the above list Aderhold (1), by means of inoculation with pure cultures, secured a limited development of the fungus on *Scorzonera hispanica*, *Daucus carota*, *Beta vulgaris*, and Apium (?), and a more vigorous growth on roots of *Phaseolus vulgaris.*

In 1905 specimens of tobacco seedlings, noted above as affected by Thielavia, were sent to this Department by Mr. Paul Ackerly, of Havana, Cuba, and the fungus was identified by Dr. Ernst A. Bessey.

SYNONYMY AND RELATIONSHIPS.

When Berkeley and Broome (5) in 1850 gave the name *Torula basicola* to the fungus which they found at the base of the stems of peas, they saw only the chlamydospore stage, which is by far the most conspicuous as the fungus is found in nature. Though classing it as a Torula, they nevertheless seemed somewhat doubtful of its exact identity, as they state that "it is a very curious species, distinguished from most Torulæ by its articulations not being constricted."

Apparently no further observations were made on the fungus until 1876, when both Zopf (56) and Sorokin (50) report having found it, the former in Berlin in 1875 on the roots of *Senecio elegans*, and the latter at Kazan, Russia, on rotten roots of *Cochlearia armoracia* (horse-radish). Sorokin found only the chlamydospore stage, and thinking it a new fungus named it *Helminthosporium fragile*. Zopf, however, made a more complete study of the fungus, and describes two conidial forms of fructification, a pycnidium with stylospores and the perfect or ascospore stage, which placed it in the Ascomycetes. No one has since observed the pycnidia mentioned by Zopf, and as he does not note their occurrence in his later publications on Thielavia, it is to be supposed that he was mistaken in his first observations. Zopf placed the fungus in the Perisporieæ and, considering it different from existing genera, created a new genus, naming it Thielavia, after one of his favorite professors at the University of Breslau, Dr. F. von Thielau. He retained the specific name *basicola* given by Berkeley and Broome, having recognized the identity of their Torula with the second fruiting form of Thielavia.

In 1882 Saccardo (39) recorded Zopf's work, but in 1886, noting the observations of Sorokin, did not agree with him in calling the fungus described Helminthosporium, believing it to be far distant from that, and placed it in the genus Clasterosporium, though with some trepidation, as he questions whether it should not be placed among the Torulæ.

Saccardo thus failed to note the identity of Sorokin's *Helminthosporium fragile* with the chlamydospore stage of Thielavia and with Berkeley and Broome's *Torula basicola*. Sorauer (47), in the same year, was the first to discover this.

The name of the fungus, with its synonymy as now recognized, is as follows:

Thielavia basicola (B. & Br.) Zopf, Sitz. Bot. Ver. Prov. Brandenb., vol. 18, pp. 101–105, June 30, 1876.
Torula basicola (B. & Br.), Ann. & Mag. Nat. Hist., Series II, vol. 5, No. 30, p. 461, 1850.
Helminthosporium fragile Sor. Hedw., vol. 15, No. 8, p. 113, August, 1876.
Clasterosporium fragile Sacc. (Sorok.) Sacc. Syll. Fung., vol. 4, p. 386, 1886.

Nearly all writers agree in placing the genus Thielavia in the family Perisporieæ of the Perisporiaceæ, thus bringing it into close relationship with Aspergillus, Penicillium, and Perisporium and with the family Erysipheæ. Tubeuf and Smith (52) state that this is the only genus of the Perisporieæ which causes a really serious plant disease. Jaczewski (27), however, in 1894, in an essay on the natural classification of the Pyrenomycetes, places Thielavia in the family Sphærellees and tribe Thielaviees, other genera closely related being Leptosphaeria, Trichothecium, and Ascospora.

Fischer (21) in 1897 considered Thielavia as a genus of the family Aspergillaceæ of the Plectacineæ, along with Aspergillus and Penicillium.

Only two other species of the genus have thus far been reported—*Thielavia bovina*, found growing on cow dung in Sicily, and *Thielavia soppittii*, found at the base of dead stems of *Carduus palustris* at Halifax, England.

ARTIFICIAL CULTURES OF THIELAVIA.

HISTORICAL DATA.

Peglion (33) in 1897 reported having grown Thielavia in pure culture on various sterilized media, among which were sterilized potato, must agar, and must gelatin. The fungus grew readily upon these, developing both the endoconidia and chlamydospores. The ascospores, however, Peglion was unable to obtain until three years later, when they were produced in 3-year-old potato cultures revived by the addition of a 0.6 per cent tartaric acid solution and kept in a thermostat at 25° C. for a number of days. No one has since reported the occurrence of perithecia in culture.

In the summer of 1903, Aderhold (1) undertook a series of inoculation experiments with Thielavia, and he states that the fungus grew easily on sterilized pear and carrot and on bouillon gelatin with pear and carrot juice or grape sugar.

Clinton (20) reports having grown the fungus on potato agar and on sterilized horse dung, though he had some difficulty in obtaining his original cultures.

ISOLATION OF THE FUNGUS.

The writer experienced considerable difficulty in isolating the fungus because of the fact that the chlamydospores taken from old diseased tobacco roots failed to germinate before being overgrown with bacteria and, further, because the fungus does not grow well upon plain beef agar. Cultures were finally secured from conidia obtained from freshly diseased rootlets, the medium used being a beef agar to which a 0.2 per cent solution of sodium nitrate was added.

Method used.—Sections of diseased rootlets showing little, if any, decomposition but presenting an abundance of spores were soaked for forty-five seconds in a 1 to 1,400 solution of mercuric chlorid and then thoroughly rinsed with distilled water. Under sterile conditions they were macerated in a watch glass containing a little sterile water. Tubes of sodium nitrate agar were inoculated from this material, dilutions made therefrom, and plates poured.

CULTURAL CHARACTERISTICS.

The fungus Thielavia has been grown on a wide range of culture media and under various conditions, and exhibits considerable difference in development under changed environments.

On practically all media the mycelial growth was confined almost entirely to the surface and immediate substratum, sometimes penetrating 5 to 10 millimeters into the latter and occasionally entirely filling it with hyphæ, but producing practically no aerial growth. So far as the writer's observations have gone, endoconidia were produced aerially only, but chlamydospores have been noted to occur all through the substratum, as in the tobacco roots they are produced within the cells of the plant as well as on the surface.

In slant cultures the excess of liquid gathered at the bottom, and in all cases the growth of the fungus was quickest and most vigorous there and the production of chlamydospores most abundant.

Growth on various agars, vegetables, etc.—On beef-agar slants at the end of five weeks, during which time the cultures were kept at room temperature (18 to 24° C.), the growth was rather scant, gray except at the bottom of the slant, where it was denser and blacker and a more copious production of chlamydospores was evident. Hyphæ penetrated the agar to a depth of 7 to 10 millimeters, and chlamydospores were produced therein.

In beef bouillon the fungus produced a slightly grayish black floating mass of mycelium, sparingly spore bearing, nearly filling the liquid.

In asparagin water the growth was less vigorous and nearly transparent, very few spores being produced.

On soil-solution agar and tobacco-root agar, growth was very scant and pale gray, the few chlamydospores produced being of a very light color.

On tobacco-leaf agar the fungus covered the slant and was quite vigorous and gray-black.

On corn meal in flasks growth was very vigorous, the production of endoconidia being very abundant two to four days after inoculation and covering the mycelium with silvery masses of spores, these being hidden later by a dense black growth of chlamydospores.

When a 0.5 per cent sodium nitrate solution was added to the corn meal the fungus was even more vigorous and produced more quickly an abundance of jet-black chlamydospores.

Steamed pear slants produced a very scanty, scattered, gray-black, sparingly spore-bearing growth.

Gelatin with beef bouillon was an even poorer medium, the fungus developing but slightly on the surface.

Steamed carrot and potato slants proved the best media found, as the fungus invariably grew vigorously and produced abundantly both conidia and chlamydospores. The mycelium penetrated and blackened the substratum in both cases and formed layers of mycelial growth from the medium to the walls of the tube over the surface of the liquid.

On corn-meal agar and pear-juice agar spore production was not great, being more abundant in the former and somewhat restricted to spots, but not covering the surface of the medium in either case.

On steamed rice growth was slow and not very dense, gradually penetrating the medium and producing chlamydospores sparingly in little clumps, the conidia being equally scarce.

On 1 per cent grape-sugar agar a very dense growth was produced on the surface and penetrating 5 to 10 millimeters into the substratum. An abundance of jet-black chlamydospores was present, giving the slant a shiny black appearance.

Growth in acid media.—A 0.05 per cent oxalic-acid agar gave a very vigorous development of the fungus on the surface and penetrating 10 to 15 millimeters into the substratum, the color being a dull black. However, when 0.2 per cent oxalic acid was added to the agar no growth could be secured, though several attempts were made.

On 0.1 and 0.2 per cent nitric-acid agar, growth was gray-black, well over the slant, slightly less in 0.01 per cent and much more vigorous and more highly spore producing in 0.02 per cent agar.

Growth in neutral-salt media.—The addition of 0.1 per cent sodium sulphate to beef agar gave a sparing development of the fungus over the surface of the slant, while 0.2, 0.5, and 1 per cent added to agars produced a denser, darker colored growth, but in colonies rather than evenly covering the surface.

On 0.1 per cent potassium-nitrate agar the fungus nearly covered the slants with a gray-black growth, but on 0.2 and 0.5 per cent agar, development was denser and blacker, in the latter case being in colonies.

On 0.1 and 0.2 per cent sodium-nitrate agar eventually an abundant growth was produced, but on 0.5 and 1 per cent the development was more scant and spore production not as great.

Growth in alkaline media.—On 0.1 and 0.2 per cent potassium-carbonate agar a spreading, scant, gray to black growth was produced, while agar containing 0.5 and 1 per cent potassium carbonate gave no development of the fungus whatever.

A 0.5 per cent calcium-hydroxid agar gave slightly more vigorous growth than an agar containing 1 per cent of the salt.

Summary.—Summarizing the results here obtained, it would seem that the presence of the various acids and salts up to a certain point, different in the case of each ingredient used, is favorable to the growth of Thielavia, while beyond that point it tends to retard, restrict, or even kill the fungus.

Moreover, the abundance and color of the chlamydospores varies with the medium employed. Oxalic-acid and grape-sugar agars and corn meal plus 0.2 per cent sodium nitrate gave notably jet-black chlamydospores in profusion, while pear and potassium-carbonate agars and pear slants produced light gray to olive colored spores.

EFFECT OF DIFFERENT TEMPERATURES.

Differences in temperature also produced marked variations in growth, especially with regard to rapidity of spore formation. Cultures of Thielavia on carrot slants, kept in an ice box at a temperature of from 8° to 11° C., grew very slowly, at the end of the third day showing only a very faint white growth along the line of inoculation, and the first sign of chlamydospore development appearing after six days.

The lower limit of growth was determined by means of the ice thermostat to be between 7° and 8° C. No growth was made in cultures kept at 1.3° C., but when these were brought into room temperature vigorous growth resulted.

At room temperature, 18° to 24° C., after two days a white, cottony growth covered two-thirds of the slant, spreading from the line of inoculation, and chlamydospores began to appear the third day.

In the thermostat at 30° C. spore formation was slightly earlier and growth considerably more vigorous and rapid. This temperature was clearly the optimum for the development of the fungus.

In cultures kept at 34° C. a curious phenomenon occurred. The fungus, instead of spreading over the entire surface of the carrot slant, as in other cases, confined its growth to a limited space adjacent to the line of inoculation, producing a dense, fluffy, gray-black mass of mycelium and spores, 2 to 6 millimeters wide along the length of the inoculation and heaped above the surface of the medium to a height of 1 to 3 millimeters, in this particular being quite different from any other cultures.

At 37° C. no growth could be secured on carrot slants. The upper limit of growth, then, is between 34° and 37° C.

SPORE GERMINATION.

Germination of both endoconidia and chlamydospores was observed in hanging-drop cultures of beef bouillon. The former germinated in eighteen hours, and in one case a spore after putting out a single hypha six cells long began the production of new conidia in large numbers, the last cell of the six functioning as an endoconidial cell. (Pl. I, figs. 2 and 3.)

The chlamydospores were from an old tobacco root and germinated after eighteen to twenty-four hours. (Pl. I, fig. 7.)

CONDITIONS INFLUENCING ATTACKS OF THIELAVIA.

The conditions prevailing in tobacco seed beds are so different from those encountered in the field, and the possible means of prevention of root-rot in the two cases are so distinct because of both the limited seed-bed space and the diverse conditions under which the plants grow, that the subjects will be treated separately.

Conditions in the Seed Beds.

In so limited a space as the tobacco seed beds, especially those in northern tobacco districts made in the most up-to-date manner with steam heat and sash covers, the various environmental factors are very largely under control, and preventive measures can be more easily carried out than in fields.

GENERAL CONCLUSIONS OF VARIOUS WRITERS.

Sorauer (48) in his study of the "root-brown" of cyclamens observed that certain conditions, especially heavy manuring, too abundant watering, and too high temperatures seemed to favor the attack of Thielavia, and he states that by changing the affected plants to a sandy, less rich soil and giving them abundant ventilation, plenty of sunlight, and not too much water, an increase of the disease was prevented. Peglion (33) further states that in hotbeds the stratum of manure may be so near the surface as to injure the roots and to predispose them to the attacks of Thielavia.

Benincasa (3), while recognizing these facts, believed that "more than all, certain weather conditions favor the development of the parasite. When the season is humid, the environment in which the young plants are compelled to live, while predisposing them to the attacks of disease, is extremely favorable to the development of the fungus. Scarcely any expedient is successful under such circumstances, either in preparing or cultivating the nursery." In addition to the measures recommended by Sorauer (48) for checking the trouble, Benincasa (3) notes the use of a 0.6 per cent KNO_3 solution for watering the plants, to stimulate the development of new secondary roots. On the other hand, solutions of manure aggravate the trouble.

RESULTS OF SEED-BED EXAMINATIONS.

In the writer's experience the worst root-rot has been found in seed beds containing soil with an abundance of humus and a considerable percentage of clay, highly fertilized either with chemicals or manure, and excessively watered. On the other hand, many seed beds with a light sandy soil containing little humus and not highly fertilized have been examined, and with very few exceptions no root-rot has been found.

EXCESSIVE FERTILIZATION.

The fact that an abundance of humus and quickly available nitrogenous fertilizers, high temperatures, and abundant watering will produce large plants in the shortest space of time has led many to use these conditions of excessive and rapid growth in the production of tobacco plants, often going to the extreme in the quantities of fertilizer and water used. The result is that the plants are made weak and especially susceptible to the attacks of Thielavia, while at the same time ideal conditions are furnished for the growth of that parasite. Many cases of serious seed-bed injury observed by the writer were connected with excessive fertilization; in some instances with chemicals containing large quantities of quickly available nitrogenous ingredients, such as nitrate of soda; in others, large quantities of hen manure were used. In addition to this fertilization previous to seeding, the practice is quite prevalent of watering the young seedlings from time to time with dilute solutions of $NaNO_3$ or manure water to hasten growth, and this in all probability aggravates the trouble.

VENTILATION.

The ventilation of the seed beds also has an effect upon the development of root-rot, though just how great it is difficult to determine because of the large number of factors which are to be considered.

Sash compared with cloth-covered beds.—It was thought at first that the disease would be found much more severe in beds covered with sash than in cloth-covered beds, because of the fact that the air becomes humid and heated by the sun, thus furnishing ideal conditions for the development of the fungus. The results of the examination of a considerable number of diseased seed beds, both sash and cloth covered, bears out this inference with very few exceptions. Nearly all of the worst diseased beds were glass covered, and the number of diseased sash-covered beds as compared with cloth-covered ones was more than two to one.

In one case where a cloth-covered bed was more severely attacked than an adjoining sash-covered one, though the disease was bad in both, the former had been diseased quite badly the previous year and thus was very heavily infected with the fungus, while the latter was attacked for the first time and the infection was consequently not as great.

Benincasa (3) states that he has seen root-rot develop in its most virulent form in seed beds covered with glass or oiled paper. All things considered, it seems reasonably sure that sash-covered beds unless very carefully ventilated are liable to more serious attacks of root-rot than are cloth-covered beds.

Crowding of plants.—The crowding of plants in the seed beds by too heavy seeding furnishes favorable conditions for the development of root-rot, at the same time causing the seedlings to be spindling and tender and thus more susceptible to the disease. This results not only from the lack of sunlight and a free circulation of air about the plants themselves, but because the dense mass of foliage of the crowded plantlets produces a damp blanket over the soil and prevents proper aeration and circulation, thus aiding fungous development.

Too heavy seeding of tobacco beds is a common fault and not altogether without cause, for the reason that tobacco seeds are so very minute that it is difficult to sow a small enough quantity. Moreover, if any wind is blowing, the seeds are apt to be unequally distributed, resulting in crowding in some spots, while others are nearly or quite bare. The best method to avoid crowding and to insure even seeding is to mix the seed thoroughly with several times its bulk of meal, ashes, plaster, dry sand, or soil and go over the bed twice, once lengthwise and the second time crosswise, sowing as small a quantity as possible each time. After a little experience with this method of sowing, even distribution of the seed can be obtained and too heavy seeding prevented, thus insuring more vigorous plants.

Benincasa (3) states that in 1902, at the tobacco agency at Pontecorvo, Italy, excessive injury from root-rot was avoided, even though the disease was more than ordinarily severe, by sowing the seed beds later and giving the plants more space.

TEMPERATURE.

The few data available from actual practice have not shown that steam-heated, sash-covered beds are more susceptible to root-rot than those which rely solely on the sun's heat. One large group of steam-heated, sash-covered beds was examined quite carefully in the spring of 1906 and comparatively little root-rot found in two or three beds. The soil, however, was of a medium light texture, and therefore not especially favorable to the development of the trouble.

Severe winters.—By some the virulence of root-rot is thought to be measurably affected by the character of the preceding winter, a severe season causing a considerable diminution of the trouble, but no direct evidence is available on this point, as no experiments have been carried out to determine the effect of freezing on the viability of the spores. However, the evidence at hand from practical men supports the statement.

SEVERE DRYING.

The result of long-continued desiccation of seed beds during the summer was in one case an increase of root-rot the following spring. As an experiment one farmer left the sash on a portion of one of his worst diseased beds all summer. The soil became so dry that every weed in the bed died and the earth was baked by the sun all summer long. The following spring the bed was prepared as usual, and the disease appeared even worse than in the previous season.

CONTINUOUS USE OF BEDS.

The result of using seed beds year after year without sterilization or change of soil is an increase of root-rot. If the bed is infected at a particular point and the conditions are favorable, the fungus will spread by growth through the soil and be scattered in the spading and preparation of the beds in the spring, so that in the course of a year or two at the most the entire bed will become infected.

NEW SOIL IN OLD BEDS.

By taking the infected soil from the beds to a depth of 10 to 12 inches and supplying fresh soil, a fairly good crop of seedlings has in some cases been grown the first year, but the spores of the fungus left about the sides or in the soil below were sufficient to infect the new soil, and by the second season at the latest the disease had reappeared in serious proportions. In one instance, however, that came to the writer's attention, new soil was added in part and mixed with old soil where the trouble was severe, with the result that the disease caused serious loss the first season.

NEW BEDS.

Even the preparation of entirely new beds every season does not insure immunity from attack, as the fungus may be introduced in so many different ways that it is almost impossible to guard against it by other means than soil sterilization, especially in sections where the disease is at all common.

GREENHOUSE EXPERIMENTS.

EFFECT UPON ROOT-ROT OF HEAVY AND OF LIGHT WATERING AND OF A SURFACE LAYER OF SAND.

Four large flats were filled with rich soil. Three were artificially inoculated with Thielavia by mixing a number of vigorous corn-meal cultures with the soil; one was left uninoculated as a check. All were kept at greenhouse temperature. Flat A was watered excessively, flat B scantily—just enough to keep the plants from wilting—and flat C received a moderate amount of water and a surface layer of sand one-half inch deep.

The experiment was terminated six weeks after sowing the seed, and out of 587 plants examined in flat A every one was badly affected with Thielavia. The disease, while present in all the remaining flats, including the check, was in no case as severe as in flat A. Next to the check, flat B showed the smallest amount of disease, 62 per cent of the plants being quite badly attacked and the remainder but slightly. In flat C none of the roots in the sand were diseased, save where the fungus had run up on a root from the infected soil below. However, a large percentage of the roots which entered the soil below were more or less diseased.

Conditions in the Fields.

CLAY SOIL COMPARED WITH SANDY LOAM.

Root-rot in the field causes by far the greater loss on soils containing a large percentage of clay and lacking in drainage; in some cases the entire crop is rendered unmarketable.

In the medium light, sandy loams the injury, though often considerable, rarely, if ever, amounts to a total loss of the crop. The loss in these cases is due to the necessity of having to reset a larger percentage than usual of plants that were too weak and were overcome by the attacks of disease, and to a retarding of the development of the affected plants, thus resulting in a reduction in the yield and in injury to the quality of the crop. In some instances the retarding of the newly set plants has been such as to cause farmers to plow up whole fields and to reset them with healthy plants. In other cases, however, the loss is hardly appreciable, though some delay is noticeable in the starting of the crop.

LOW SPOTS.

The greater injury to tobacco in low spots in fields is attributed by some growers to the burning of the roots by an excess of some constituent of the commercial fertilizers used which by washing and seepage has accumulated there. A grayish white incrustation was found quite general on the soil in badly diseased spots. An analysis of this made by the Bureau of Soils, in comparison with soil from 2 to 4 inches below the surface and soil from a healthy portion of the same field at a similar depth, gave a very large excess of soluble nitrates, sulphates, and chlorids in the first case and a considerable increase in the second above the content of healthy soil, the percentages of these soluble salts being, respectively, 0.7 per cent, 0.2 per cent, and 0.06 per cent. Professor Whitney, who made the analysis, further states that this examination would indicate that an excessive accumulation of soluble salts is the probable cause of the trouble with the tobacco plants grown on this soil.

The presence of this excessive amount of soluble salts may be injurious to the plant roots and thus render them more susceptible to the attacks of the fungous parasite. The cultural experiments described have shown that Thielavia grows more vigorously in the presence of 0.2 per cent of various salts than in the presence of smaller amounts, and therefore that the excessive use of fertilizers also favors the growth of the fungus.

HIGH FERTILIZATION.

Just what relation the high fertilization of tobacco fields in vogue in many places has upon the development of root-rot can not be answered conclusively at this time, though work is being done along this line by Dr. L. J. Briggs, of the Bureau of Plant Industry. As the result of fertilizer experiments already completed, he concludes (6) that the root-rot "fungus attacks the tobacco roots most severely when the soil has become alkaline, due to the use of too large amounts of lime, ashes, or fertilizers containing carbonate of potash."

ROTATION OF CROPS.

Numerous field observations have been made on the effect of crop rotation upon the virulence of root-rot of tobacco. In a field of a number of acres comprising one portion previously in tobacco and another which had been in corn, there was a distinct line of demarcation between the two portions of the field—that previously in tobacco having the disease much worse than the other, the plants being stunted and sickly and exhibiting considerable Thielavia on their roots, while tobacco on the corn land was larger and more vigorous and healthy in appearance and was little affected by Thielavia. The same marked difference has been noted between old tobacco fields and new lands adjoining just brought into cultivation. The growing of grass on tobacco land for one year has likewise caused a striking decrease in the amount of root-rot and an increase in the vigor of the resulting crop.

In one instance a field which had been in tobacco continuously for a number of years and showed considerable root-rot was enlarged by including a strip of land 5 to 15 feet wide on two sides which had not been cultivated but had borne a growth of weeds. The tobacco on this fringe was distinctly larger and more vigorous and had less Thielavia.

EXPERIMENTS.

Result of setting diseased plants in the field.—A point of great practical importance to the farmer with diseased beds is to know whether or not the injured plants may be set in the fields with fair prospects of a crop. Benincasa (3) says that the transplanting of the young diseased plants does not insure success in the cultivation, and observations by the writer bear out the statement with few exceptions.

To determine the effect of setting diseased plants in a field free from the disease, the following experiment was carried out with the assistance of Mr. J. B. Stewart, of the Bureau of Plant Industry:

Four hundred and fifty Havana Broadleaf plants, every one affected in some degree with root-rot, were selected from a diseased bed, and a like number of perfectly healthy plants of the same variety was secured from another source. These were set by machine in two long rows side by side in a field of medium light, sandy loam, the healthy plants being set first to avoid danger of infection. The diseased row was at first noticeably retarded, no growth being apparent for a period of ten days to two weeks. The plants finally gained the ascendency over the disease, and, although slightly behind the healthy row for most of the season, caught up at the last, and shortly before harvesting time little, if any, difference was apparent in either the size or the vigor of the plants. The diseased row yielded 1 pound more of cured tobacco than the healthy one and from a smaller number of plants, as quite a number of mosaic plants were discarded from the diseased row. The mosaic disease was much worse in the diseased row than in the healthy one. However, we have no conclusive evidence that the presence or absence of root-rot has any connection with the virulence of the mosaic disease. Upon examination of the root systems of full-grown plants from the diseased row, the lower portion of the taproot was found to be shriveled, black, and dead from Thielavia attacks, but a vigorous production of lateral roots which were perfectly healthy and showed no signs of root-rot had taken place above.

Although in point of yield the two rows may not be strictly comparable, as the plants were doubtless of slightly different strains, though of the same variety, and were also from different sources, the experiment showed that under the particular conditions in which the plants were grown the disease did little appreciable damage.

An instance with a like result came to the writer's notice during the season of 1906. A farmer pulled from his beds sufficient plants to set half an acre, but upon finding them so badly diseased that the root systems were largely rotted off decided not to set them, placing the seedlings in the cellar instead. After three or four days the plants developed new roots, and they were set in one corner of a large field of quite light, sandy loam. They made no growth for ten days to two weeks, and healthy plants set in the adjoining field some days later started off much more rapidly. However, at the end of the season no appreciable difference could be noted in either vigor, yield, or quality. The roots exhibited the same appearance as in the case already noted.

Result of setting healthy plants in infected soil.—A second experiment was made on a smaller scale in which diseased seedlings were set in a noninfected field and healthy ones in a diseased seed bed after the removal of the seedlings. In the first case the result was almost identical with the experiment already noted, the soil being very similar. In the latter case, however, the healthy seedlings became quite badly diseased, were notably stunted, and a large percentage failed to produce mature plants that were marketable.

In the greenhouse sixty-six plants of Connecticut Havana tobacco were grown in pots of uninfected soil until 4 to 6 inches high, and then twenty were inoculated by mixing some infected soil from a Connecticut seed bed with the soil in which they were growing. The remaining plants were kept for checks. At the termination of the experiment the inoculated plants were without exception from 4 to 6 inches shorter than the check plants and showed considerable root-rot besides a general unhealthy appearance.

Conclusions.—While these experiments would indicate that sometimes diseased plants may be set in the field without danger of loss, the writer would not recommend such action. All the soils in which these experiments were carried out were of very light texture and unfavorable to the development of root-rot. On heavier soils the disease has caused large losses, due both to the stunting and to the killing of the plants. Moreover, the initial retarding of the plants delays maturity, and delayed maturity always affects the quality of the crop injuriously. It also increases the danger of the crop being caught by frost. In a large field the percentage of plants that have to be reset because of irreparable injury due to Thielavia is in most cases much larger than ordinarily, while in a number of cases that have come to the writer's attention whole fields have been plowed up and reset with healthy plants.

REMEDIAL TREATMENT IN THE SEED BED.

Sorauer (48) seems to have been the first to devise methods of reducing the injury from Thielavia, the host attacked being in his case the cyclamen. Since that time Selby (44) and Clinton (20) in America and several workers in Italy have experimented with methods of reducing or eliminating the loss occasioned by Thielavia in tobacco beds.

The measures which may be employed may be divided into two classes, preventive and palliative. The former relates to all methods of eliminating the disease by killing the fungus which occasions it. Under the latter are included all those means which tend to reduce loss because of the partial or total elimination of conditions of soil, air, and temperature favoring the development of the fungus or because of the production of plants resistant to the disease.

PREVENTIVE MEASURES.

STEAM STERILIZATION.

The preventive method which promises best results to those who have the conveniences for applying it is that of sterilization of the seed beds by steam.

In addition to the killing of the fungus, this method, in common with surface firing, to be described later, has several advantages over formalin treatments. The weed seeds in the soil are very largely killed, and this alone, according to the testimony of the farmers who have used sterilization, pays for the cost of treatment, as the beds do not have to be weeded and thus a large amount of hand labor is obviated. The physical texture of the soil is altered by the heat and made more suitable to root development and, moreover, considerable plant food is made directly available to the seedlings. Furthermore, the heating of the soil just before sowing in the spring has an appreciable effect in starting the seedlings off quickly.

With the elimination of the fungus it is possible to employ those methods of forcing the plants by extra fertilization, increased watering, and higher temperatures which would otherwise be unsafe as favoring the development of the root-rot fungus.

Ordinary greenhouse method.—The method of sterilization to be used will depend to some extent on the size, the location, and the permanency of beds and the cost of application.

The method in general use for the sterilization of soil in greenhouse benches might advantageously be employed in beds that are to be used year after year without change of location, as the equipment would be more or less permanent. This consists in placing 1 foot below the surface of the soil a system of 1½-inch pipes which are perforated with ¼-inch holes on their under side at intervals of 6 inches throughout their entire length. The pipes should run lengthwise of the bed, 18 inches apart, and be connected with a steam boiler capable of producing 80 to 100 pounds pressure. Before treatment the soil should be thoroughly spaded up and pulverized to permit ready access of the steam to all parts, and all fertilizers except commercial ones should be applied at this time, since fresh spores of the fungus might be carried in if manure were added after sterilization. Commercial fertilizers, however, contain no Thielavia spores and may be applied subsequently. Preferably, however, they should be applied before sterilization and the seed sown the following day.

The bed to be treated should be covered with several thicknesses of old burlap or blankets to confine the heat to the soil. The steam should be applied at a pressure of 80 to 100 pounds, as at high pressure it is much drier and the soil is not wet as much as when low-pressure steam is used. A treatment of from one to two hours is usually sufficient to thoroughly sterilize the soil to a depth of 18 inches. A few potatoes laid in the surface soil will indicate the thoroughness of the treatment by the degree to which they are cooked. The blankets might advantageously be left on for some time to make the treatment more thorough.

While this method offers some advantages for seed beds of limited area, in that the pipes may be left in the ground and used year after year with little extra labor and may also be used for subirrigation, the initial cost of installation, especially on large seed-bed areas, may be prohibitive.

Steam-rake method.—The method of sterilization by a steam rake has not proved successful in practice. The implement is in the form of a rake made of hollow, perforated pipes, which are forced into the thoroughly pulverized seed-bed soil and through which the steam is applied. The difficulty is that the steam, instead of permeating the soil, follows the path of least resistance and escapes up the side of the teeth.

Inverted-pan method.—The method which has given the best results in practice, and which because of its simplicity and small cost recommends itself for use on large or small areas, is the invention of Mr. A. D. Shamel, of the Bureau of Plant Industry, and was devised by him to sterilize nematode-infested soils in Florida. The apparatus consists of a galvanized iron pan, 6 by 10 feet and 6 inches deep, which is inverted over the soil to be sterilized and the steam admitted under pressure. The pan is supplied with steam hose connections, has sharp edges, which are forced into the soil on all sides to prevent the escape of steam, and is fitted with handles for moving it from place to place, the weight of the entire pan being not over 400 pounds.

The soil is prepared as in the greenhouse method, a few potatoes being buried at a depth of a foot to gauge the degree of heat attained. A soil thermometer may also be used if desired. The steam should be kept at as high a pressure as possible, 80 to 100 pounds being best, and the treatment should continue for one to two hours, depending on the pressure maintained. In experiments conducted in the spring of 1907, one hour's steaming at 80° C. under 100 pounds pressure gave best results in killing both the fungus and the weed seeds. When one section of the bed is treated the pan is lifted and carried to an unsterilized portion and the operation repeated until the entire bed is steamed. (Pl. V, fig. 2.)

SURFACE FIRING.

The surface firing of seed beds has been a common practice for years in some tobacco sections, particularly Kentucky and the South, the end in view being the improving of the tilth of the soil and the killing of weed seeds rather than of any fungous disease, though in all probability this custom accounts for the fact that little trouble is known to occur in such sections from root-rot. In Italy, as well, burning is now considered a part of the regular method of seed-bed preparation, it having been resorted to as a preventive of root-rot.

Direct firing.—Two methods of surface firing are in vogue, the first by direct firing and the second requiring the use of a pan. In direct firing, the land to be sterilized is first thoroughly pulverized and manure applied. It is then covered with straw, brush, and wood sufficient to make a hot fire. This is ignited and allowed to burn for an hour or so, and then moved along to a new adjacent spot. The ashes are raked into the surface soil and the seed is sown.

Pan firing.—The second method consists in the use of a sheet-iron pan, 3 by 9 feet, under which a fire is made. This is set in the middle of a 9-foot bed and the soil on one side to a depth of 6 inches is shoveled in and heated, great care being taken to keep it moist, otherwise the humus would be burned out and the physical texture irreparably altered. After an hour this soil is put back and that from the other side of the pan subjected to the same treatment and then the pan moved along to a new place. The soil underneath the pan itself is thereby subjected to heat for two hours.

FORMALIN STERILIZATION.

The use of a formalin solution for the sterilization of greenhouse soil and of tobacco seed beds against Rhizoctonia has been in vogue for some time with excellent results, and furnishes a very simple means of combating the root-rot. The method is as follows: The beds are thoroughly prepared the same as for the other methods of sterilization described and are then drenched with a formalin solution composed of 1 part of commercial formalin to 150 to 200 parts of water, three-fourths to 1 gallon of this solution being used to the square foot of bed space. The solution should be put on with a watering pot with a rose and distributed as evenly as possible over the bed, so as to thoroughly wet the soil to the depth of a foot. It will in most cases be necessary to put this solution on in two or three applications, as the soil will not take in this quantity of water immediately. The beds should then be covered with heavy burlap or a tarpaulin to keep in the fumes for a day or so, and then aired for a week before sowing the seed.

Spring applications of formalin are open to the following objections: The addition of such a large quantity of water to the soil keeps it wet and cold for some time longer than would naturally be the case, thus delaying germination as well as subsequent growth; the necessity of airing the beds to remove the formalin fumes and to allow the soil to dry out also causes delay in seeding. To obviate this difficulty the beds should be treated in the fall, before freezing weather sets in. In this case a stronger solution, 1 to 100, may well be used, as there will of course be no danger then of injuring the seedlings.

COMPARATIVE EXPERIMENTS WITH STEAM AND FORMALIN STERILIZATION.

Numerous greenhouse experiments have been made to determine the comparative merits of steam and formalin sterilization, and a seed-bed trial was carried out in cooperation with Messrs. A. D. Shamel and J. B. Stewart, of the Bureau of Plant Industry, involving a comparison of steam sterilization, surface firing, and formalin drenching as means of preventing the tobacco root-rot.

Steam sterilization.—To determine the effect of different degrees of heat and different lengths of steam treatment of soil upon the development of Thielavia the following experiment was made: Six 8-inch pots were filled half full of good greenhouse soil, and sufficient soil to fill them was added from a badly diseased tobacco seed bed in Connecticut. They were then autoclaved one and one-half hours at 20 pounds pressure at 126° C. On the following day four of these were again autoclaved in the same manner, and two again on the third day. Two unsterilized 10-inch pots of the same infected soil were used for checks, and all were sown on the same day with Connecticut Havana seed. Germination was rather uneven in all the pots. After three weeks a considerable number of seedlings in the check pots damped-off with Thielavia, but those in the steam-treated pots were perfectly healthy, and a week later were two to three times as large as the survivors in the check pots. These remained much smaller and were sickly in appearance throughout the experiment. (Pl. IV, fig. 3.)

At the end of eight weeks the plants in all the pots were pulled and found in the following condition:

Check pots: Plants distinctly stunted and foliage a sickly yellow color characteristic of root-rot. Roots of all plants badly diseased with Thielavia.

Pots autoclaved one day: Plants deep green, vigorous, and healthy. A small amount of Thielavia on the roots of one plant.

Pots autoclaved two days: In one pot no germination occurred; in the second pot the plants were quite vigorous and healthy and no Thielavia was found.

Pots autoclaved three days: Plants fairly vigorous and healthy, though somewhat crowded. Root systems perfectly healthy.

The result of this experiment was that in five sterilized pots one plant only was slightly attacked by Thielavia (doubtless owing to chance reinfection after sterilization), while every plant in the two untreated pots was badly diseased.

The experiment was repeated with the same pots, the soil being reinfected by mixing it with infected soil and cut-up, diseased tobacco roots and allowed to stand two days before treatment.

Two pots were autoclaved one and one-half hours at 102° C., 1 pound pressure; two pots were autoclaved one and one-half hours at 108° C., 5 pounds pressure; two pots were autoclaved one and one-half hours at 126° C., 20 pounds pressure; two pots were left for checks.

All pots were sown on the same date with Connecticut Havana seed. Germination was good in all. As in the previous experiment, by the end of the fifth week a very large majority of the plants in the check pots had been killed by the attacks of Thielavia, only a few scattering, stunted plants remaining, while in the sterilized pots no signs of Thielavia were to be seen. At the end of eight weeks plants were pulled from the sterilized pots, and the roots were found perfectly healthy. When the few plants left in the check pots were pulled, all were found to be diseased.

Formalin sterilization.—To test the effect of different strengths of formalin solution used as a drench to prevent root-rot, the following experiments were made:

Three boxes 10 by 32 by 6 inches were filled with rich potting soil and thoroughly inoculated with Thielavia by mixing with the top 2 or 3 inches of soil a considerable quantity of a pure culture of Thielavia on corn meal. One was kept for a check, and the other two were treated the next day with formalin solution as follows: Box A was drenched with a 1 to 200 formalin solution, three-fourths gallon being used to the square foot of surface; box B was treated in like manner with a 1 to 300 formalin solution. The boxes were allowed to stand for several days to permit the formalin fumes to escape and the soil to dry out.

At the end of two weeks the plants in the treated boxes were healthy and vigorous, while the check showed poorer germination, the plants were not as vigorous, and some Thielavia was to be found.

At the expiration of three weeks the plants in the treated boxes had continued their vigorous growth, while the check showed plants small, much diseased, scattered, and sickly in appearance. Many were dead from root-rot. The experiment was terminated at the end of six weeks and the plants pulled and examined (see Pl. III, fig. 3), with the following results:

Check box: Plants very scattering, sickly green in color, 1 to 2 inches tall; 148 plants examined and every one found diseased with Thielavia.

Box A, treated with 1 to 200 formalin solution: Plants vigorous and healthy in appearance, 5 to 7 inches tall. About 500 plants examined and Thielavia found on the roots of one plant; roots of the remainder perfectly healthy.

Box B, treated with 1 to 300 formalin solution: Plants healthy in appearance, 6 to 8 inches tall. Out of 268 plants examined 93 were found perfectly healthy and 175 diseased by Thielavia—some very slightly, some badly.

The experiment was repeated with slightly different results, as follows:

Check box: Plants very badly diseased with Thielavia.

Box A, treated with 1 to 200 formalin solution: Considerable Thielavia present.

Box B, treated with 1 to 300 formalin solution: There was a very little Thielavia on 8 roots out of the large number of plants in the box, the remainder being entirely healthy.

The disease in box A may have been due to reinfection from the check or from some other source. Owing to the absence of the writer the experiment was run much longer than it should have been, and the plants being excessively crowded in the box made a very weak, spindling growth, thus rendering them especially susceptible to the attacks of Thielavia.

Seed-bed trial of sterilization methods.—To test thoroughly the steam and formalin methods of sterilization, together with that of surface firing, under actual seed-bed conditions, the following experiment was carried out in the spring of 1907 at Simsbury, Conn., in a seed bed which had been badly diseased the preceding year. (Pl. IV, fig. 1.)

It should be stated at this point that while the plans were outlined by the writer, all material from the several beds examined by him from time to time, and the conditions of the beds noted at the termination of the experiment, the work of preparation, treatment, and subsequent care of the seed beds was done by Mr. J. B. Stewart, owing to the fact that other work prevented the writer from giving the experiment personal attention.

A diseased bed, 62 feet long and 6 feet wide, was divided into 7 sections, which received different treatments, as illustrated in the following diagram:

Section 1 (10 feet).	Section 2 (8 feet).	Section 3 (8 feet).	Section 4 (8 feet).	Section 5 (8 feet).	Section 6 (10 feet).	Section 7 (10 feet).
Open wood fire. 1 hour.	Check. Untreated.	Formalin, 1 to 200. Three-fourths gallon per square foot.	Formalin, 1 to 300. Three-fourths gallon per square foot.	Steam. Soil heated to 200° F. for ½ hour.	Steam. Soil heated to 175° F. for 1 hour.	Steam. Soil heated to 150° F. for 1½ hours.

The soil was thoroughly spaded up and fertilizers added before treatment. The sections were separated by 1-inch boards inserted several inches into the soil and extending 4 to 6 inches above it. The various sterilization treatments were given April 15 and the Havana Broadleaf seed put to sprout in moist apple-wood punk and sown four days later. The beds were then covered with cheese cloth, which was kept on during the early part of the experiment until warm weather set in.

On section 1 a fire of brush and wood was burned for an hour and the ashes raked into the topsoil.

On sections 3 and 4 the formalin solution was applied with a watering pot with a rose. The solution was put on in several installments, as the soil would not take it all up at once.

Sections 5, 6, and 7 were steam sterilized by the inverted-pan method (described on p. 35). Section 5 was treated for a half hour after the soil had reached a temperature of 200° F. as indicated by a soil thermometer inserted 6 to 8 inches below the surface of the soil. Section 6 was treated one hour at a temperature of 175° F., and section 7 one and one-half hours at a temperature of 150° F.

The following notes made by Mr. Stewart give the condition of the beds on the dates stated:

April 26. Plants coming up on all steam-sterilized and check sections, but none showing on formalin or open-fire burnt sections.

April 30. Plants on all steam and fire sterilized and check sections up and growing nicely, but plants on formalin-treated sections are not coming up; only very few plants can be found, and these are small and weak.

May 6. Plants on all sterilized beds except formalin treated doing nicely. Steam-sterilized and check sections look best; plants are largest. Then comes the open-fire section. On formalin sections plants just coming up.

May 14. Plants all doing very nicely for cloth beds. Steam-sterilized and check sections about same in advancement, and fire and formalin treated about the same. Formalin-treated beds brisking up, though plants are thinner than on other sections.

May 21. In steam-sterilized sections plants too thick; in formalin-treated sections too thin; check and fire-sterilized sections about right. Steamed sections at least one week ahead of others. These were thinned and whole bed fertilized with one-third pail of a special fertilizer and well watered down. No disease showing as yet.

On May 30, plants from several beds were sent by Mr. Stewart to the writer, who examined them with the following results:

Section 7, steam sterilized one and one-half hours at 150° F. No disease.

Section 1, open-fire sterilized. A few plants slightly diseased.

Section 3, formalin treated, 1 to 200. One plant slightly diseased.

Section 2, check. A few plants diseased.

Mr. Stewart's notes continue as follows:

June 7. Plants in steamed sections ready to set; show no disease. In formalin-treated sections, one week behind. No disease yet definite. Check, all plants diseased.

On June 12, about 100 plants from each bed were pulled and sent to the writer, who examined them with the following results:

Section 1, fire sterilized. Plants 2 to 3 inches tall, healthy in appearance. No Thielavia found.

Section 2, check. Plants one-half to 2 inches tall, stunted and badly diseased. Thielavia abundant.

Section 3, formalin treated, 1 to 200. Plants 3 inches tall. Thielavia found on quite a number, though not bad as yet.

Section 4, formalin treated, 1 to 300. Plants 2 inches tall. Thielavia found on a considerable number; none bad enough to be noticeable to the naked eye without careful examination.

Section 5, steamed one-half hour at 200° F. Plants 2 to 3 inches tall, healthy. A very small amount of Thielavia found. The great majority of roots perfectly healthy.

Section 6, steamed one hour at 175° F. Plants 3 to 4 inches tall, healthy. No Thielavia found.

Section 7, steamed one and one-half hours at 150° F. Plants 4 to 6 inches tall, healthy, and with good root systems. Practically free from Thielavia, though a few rootlets were found showing the trouble in slight measure.

The following notes are also by Mr. Stewart:

June 20. Five thousand plants pulled for setting from three steamed sections.

June 27. Eleven thousand plants taken from same sections and some from open-fire section. No plants were pulled for setting from either formalin-treated or check sections.

On July 9, about 100 plants were pulled from each bed and sent to the writer, who examined them with the following results:

Section 1, fire sterilized. Out of 106 plants examined, 40 were perfectly healthy and 66 diseased—a few quite badly, the majority moderately.

Section 2, check. Ninety-nine plants, all diseased from moderately to very badly.

Section 3, formalin treated, 1 to 200. Eighty-five plants badly diseased.

Section 4, formalin treated, 1 to 300. Ninety plants, all more or less diseased.

Section 5, steamed one-half hour at 200° F. Sixty plants badly diseased; 25 slightly, if at all.

Section 6, steamed one hour at 175° F. Seventy plants healthy, 13 slightly diseased.

Section 7, steamed one and one-half hours at 150° F. Plants very healthy in appearance, 80 with healthy root systems, 20 slightly diseased.

On July 12 the beds were examined by the writer and found in the following condition, which also summarizes the results of the trial, the sections being treated in the order of their excellence. None of the beds were weeded during the experiment.

Section 6, steamed one hour at 175° F. Best bed in every respect, all plants dark green and healthy, almost entirely free from disease. Hardly a weed in the plat. (See Pl. IV, fig. 2.)

Sections 5 and 7, steamed one-half hour at 200° F. and steamed one and a half hours at 150° F. About the same in appearance as section 6, although slightly more disease present in both plats, but not enough to do any real harm. A very few weeds were left in both beds.

Section 1, surface-fire sterilized. Not as healthy in appearance as steamed sections. Considerable disease to be found all over the plat. Somewhat weedy.

Section 4, formalin treated, 1 to 300. Disease found on most plants, sometimes quite bad. Plants sickly in appearance. Badly overgrown and choked by weeds.

Section 3, formalin treated, 1 to 200. Disease found on every plant; on some very bad. Choked by weeds; even worse than section 4.

Section 2, check. Plants very scattering, many dead, very badly overgrown by weeds. Remaining plants all more or less diseased, many very badly.

To summarize, the steam treatments gave excellent results, the surface-fire treatment fair returns, while the two formalin-treated plats were little better than the untreated check plat.

Several reasons may be advanced to account for the failure of the formalin treatment. The seed was probably sown too soon after the treatment, so that the fumes of formalin had not fully escaped from the soil, and retarded and injured the germinating seedlings. Moreover, the soil had not dried out sufficiently, so that the bed was wet and cold. Both of these conditions would tend to produce weak plants easily attacked by the fungus from the adjoining check plat, which was separated by a board partition only. Fall application of the formalin would obviate both of these difficulties and, moreover, a stronger solution, 1 to 100, could advantageously be used with greater certainty of securing good results.

However, until further experimentation has fully adapted the formalin treatment to practical usage, steam sterilization stands as the best means of preventing tobacco root-rot.

PALLIATIVE MEASURES.

The measures now to be cited are purely secondary to the preventive remedies above described, and serve merely to reduce to a greater or less degree the amount of disease.

Soils containing a good proportion of sand should be used for seed beds and heavy clays avoided or lightened by the addition of sand.

Excessive fertilization and watering should be avoided, and if sash are used thorough ventilation should be given.

The making of new beds each year has in some cases obviated the trouble, though some instances have been noted where the disease has been bad in perfectly fresh beds.

The use of fresh soil in old beds is a doubtful expedient, as spores are inevitably left on the sides of the beds and in the soil beneath, and these may readily infect the new soil and render the work futile. Several instances have come to the writer's attention in which this has been done, with the result that the disease has been as bad as or worse than during the preceding year.

Special care should be taken to avoid too heavy seeding of the beds and subsequent crowding of the plants.

Several Italian writers, Peglion, Benincasa, and Campbell, report differences in resistance to root-rot in the varieties of tobacco in cultivation. At both the Pontecorvo and the San Sepolcro tobacco agencies the varieties Brasile Beneventano and Seedleaf showed the greatest resistance to root-rot, while the Kentucky and the Burley were especially susceptible. Moreover, Benincasa states that "it is an established fact that the indigenous varieties offer a resistance to root-rot much greater than that of exotic varieties, the seed of which is imported every year from their native country."

So far as known, no observations have been made along this line in this country.

SUMMARY.

Root-rot of tobacco is a disease causing the death or dwarfing of the plants in the seed bed and in the field. The trouble has been especially serious for the last few years in the tobacco-growing sections of Connecticut, where it has caused considerable loss.

The disease is due to the attacks of the fungus *Thielavia basicola* upon the roots of the plants.

The fungus belongs to the family Perisporiaceæ and produces three kinds of spores, by means of which it is disseminated. It has been found in seven countries parasitic on twenty-five different host plants.

Thielavia has been grown in artificial culture on a wide range of culture media and its life history studied.

The conditions conducive to serious injury from root-rot are: (1) Infection of the seed bed or the field with *Thielavia basicola*; (2) a fairly heavy soil rich in humus; (3) excessive fertilization; (4) heavy watering in the beds; (5) lack of ventilation in the beds.

The sterilization of infected seed beds by the methods herein described furnishes an effective means of preventing the disease.

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2. BARBATELLI and STAZI. [Note of occurrence of Thielavia at tobacco agency, Scafati, Italy.] Bol. Tecnic. d. Coltiv. d. Tabacchi, an. 1, no. 3, p. 152. Scafati, 1902.

3. BENINCASA, MICHELE. Ricerche sui mezzi per difendere i semenzai di tabacco dal "marciume radicale" causato dalla Thielavia basicola Zopf. Bol. Tecnic. d. Coltiv. d. Tabacchi, an. 1, no. 1, pp. 24–33. Scafati, 1902.

   Experiments with different characters of seed-bed soil in their relation to tobacco root-rot, and with various preventive methods.

4. ——— Come si coltiva il tabacco. Roma, 1907.

   See pt. 2, pp. 16, 30–31, fig. 10. Describes and illustrates methods of burning seed beds as the only means of preventing Thielavia root-rot.

   See pt. 3, p. 157. Note on the relative resistance of Burley and Maryland tobaccos to root-rot.

5. BERKELEY, M. J., and BROOME, C. E. Notices of British fungi. Ann. and Mag. Nat. Hist., s. 2, vol. 5, no. 30, p. 461. London, 1850.

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Describes a brown-root of lupines as a new disease due to Thielavia and gives a description of the fungus and a list of its hosts.

PLATES.

DESCRIPTION OF PLATES.

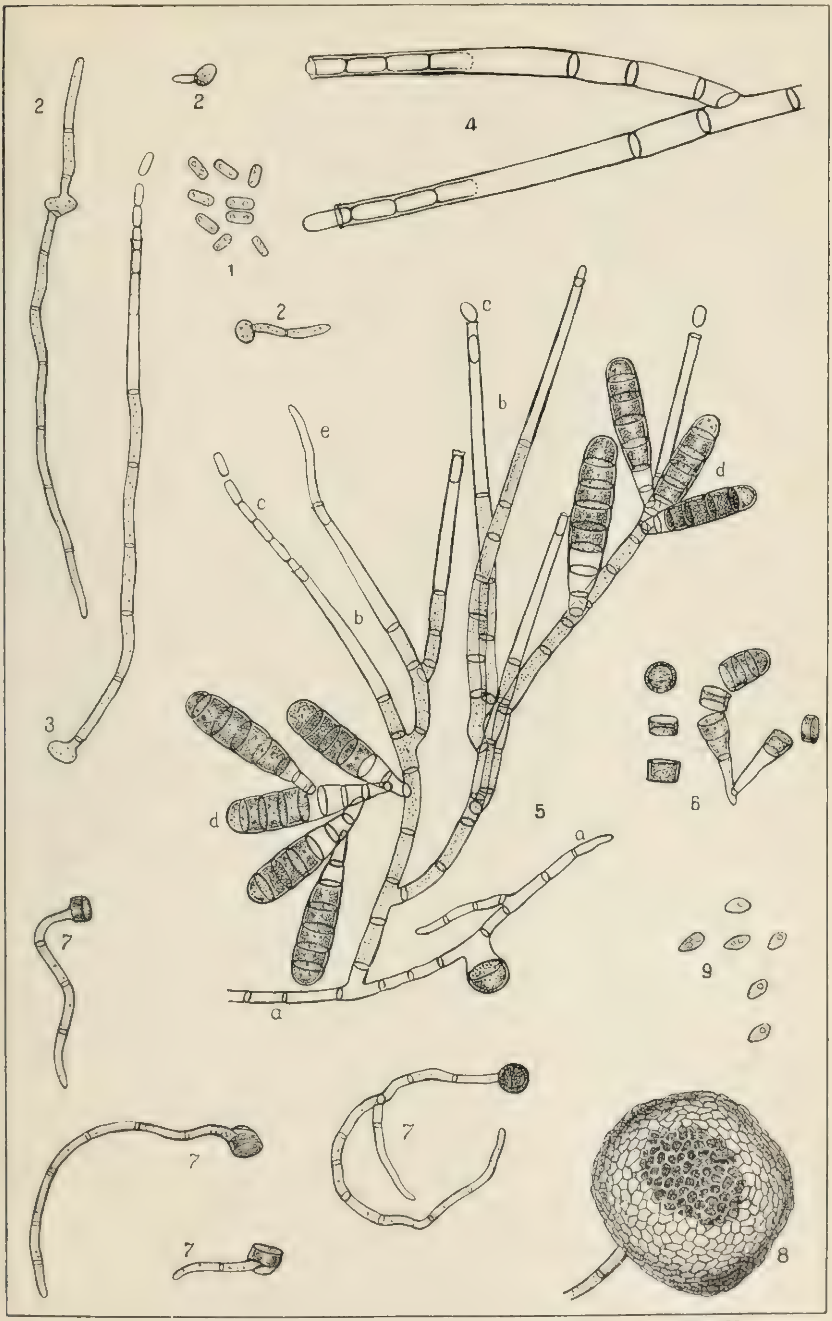
Plate I. Microscopic characters of the root-rot fungus (*Thielavia basicola* Zopf). 1.—Endoconidia. 2.—Different stages in the germination of the endoconidia. 3.—Endoconidia germinated and producing new endoconidia. 4.—Endoconidiophore, enlarged, showing formation and ejection of endoconidia. 5.—(A) Mycelium. (B) Endoconidial cell. (C) Endoconidia being pushed out. (D) Chlamydospores. (E) Endoconidium germinating in situ. 6.—Chlamydospores breaking up into segments. 7.—Chlamydospore segments germinating. 8.—Perithecium. 9.—Ascospores.

Plate II. Demonstration of parasitism of Thielavia. Both dishes shown were fitted with moist blotting paper and sterilized in an autoclave. Tobacco seed was then sown, and four days later, when the seed was germinating, dish A was inoculated with a pure culture of Thielavia. Dish B was left uninoculated. The photograph here reproduced was taken two weeks after inoculation.

Plate III. Fig. 1.—Root-rot on a small tobacco plant grown in sterilized soil and inoculated at the age of two months with a pure culture of Thielavia. Many small rootlets are blackened and dead. Fig. 2.—Badly diseased root system of a tobacco plant from a field at Suffield, Conn., showing all the roots rotted off close up to the stem. Fig. 3.—(A) Root systems of tobacco seedlings grown in sterilized soil inoculated with pure culture of Thielavia and subsequently treated with a formalin solution 1 to 200. (B) Root systems of tobacco seedlings in the same inoculated soil untreated with formalin, badly diseased with root-rot.

Plate IV. Fig. 1.—Tobacco bed at Simsbury, Conn., badly diseased with Thielavia root-rot in 1906. Plants scattered, stunted, and sickly in appearance. Fig. 2.—Tobacco plants in the same bed in 1907 after it had been steam sterilized for one hour at 175° F. by the inverted-pan method. Note the full stand of vigorous, healthy plants and the absence of weeds. No weeding had been done in this bed. Fig. 3.—(A) Tobacco seedlings grown on soil from a badly diseased bed at Simsbury, Conn. The root systems are all diseased with root-rot. (B) Seedlings on the same soil which had been steam sterilized for one and one-half hours at 120° C. The root systems of all plants are perfectly healthy. Pots A and B were sown on the same day.

Plate V. Fig. 1.—A spot in a tobacco field at Simsbury, Conn., badly diseased with Thielavia root-rot. Note the stunted condition of the plants in the foreground as compared with those on the left. The root shown in Plate III, figure 2, was from such a spot as this. Fig. 2.—A tobacco seed bed being sterilized with steam by the inverted-pan method. The steam is conducted from the boiler on the right, underneath the pan, by a hose. Note the soil thermometer at ×, inserted 6 or 8 inches below the surface of the soil.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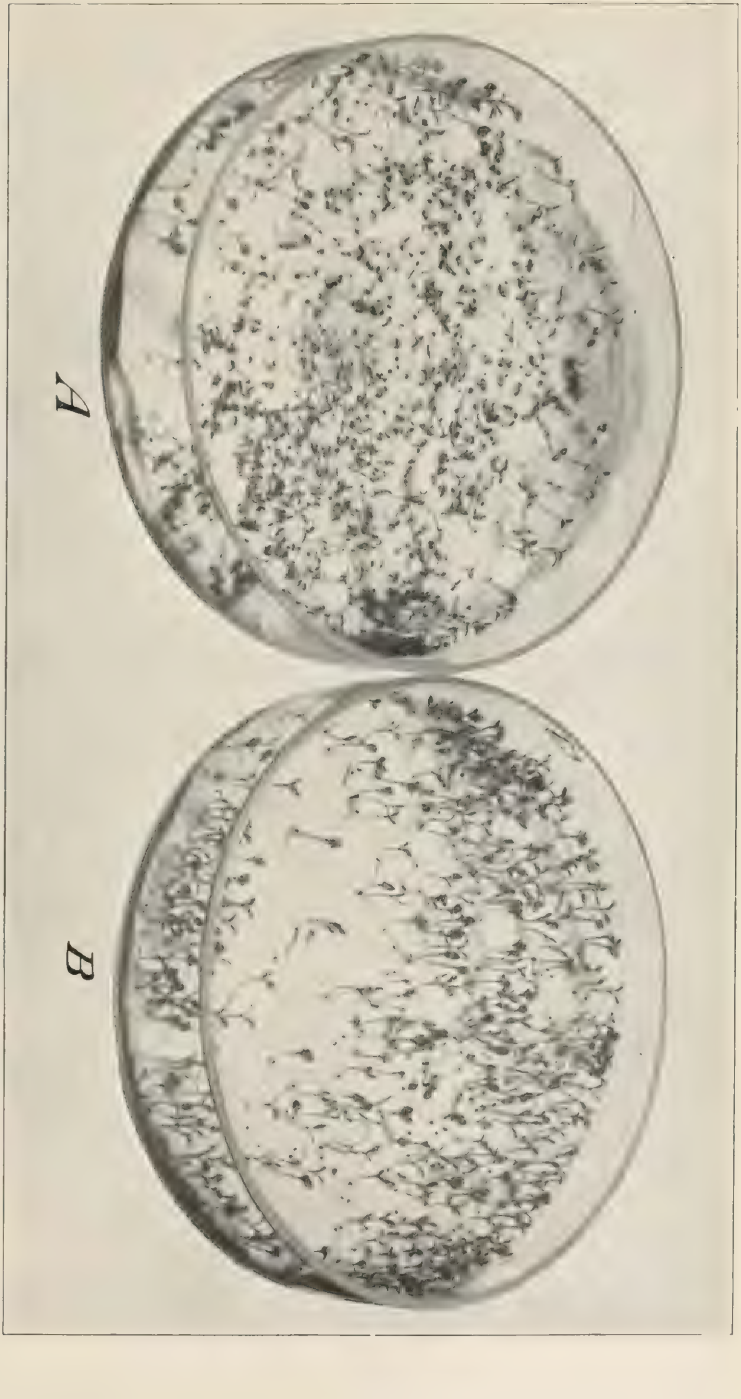
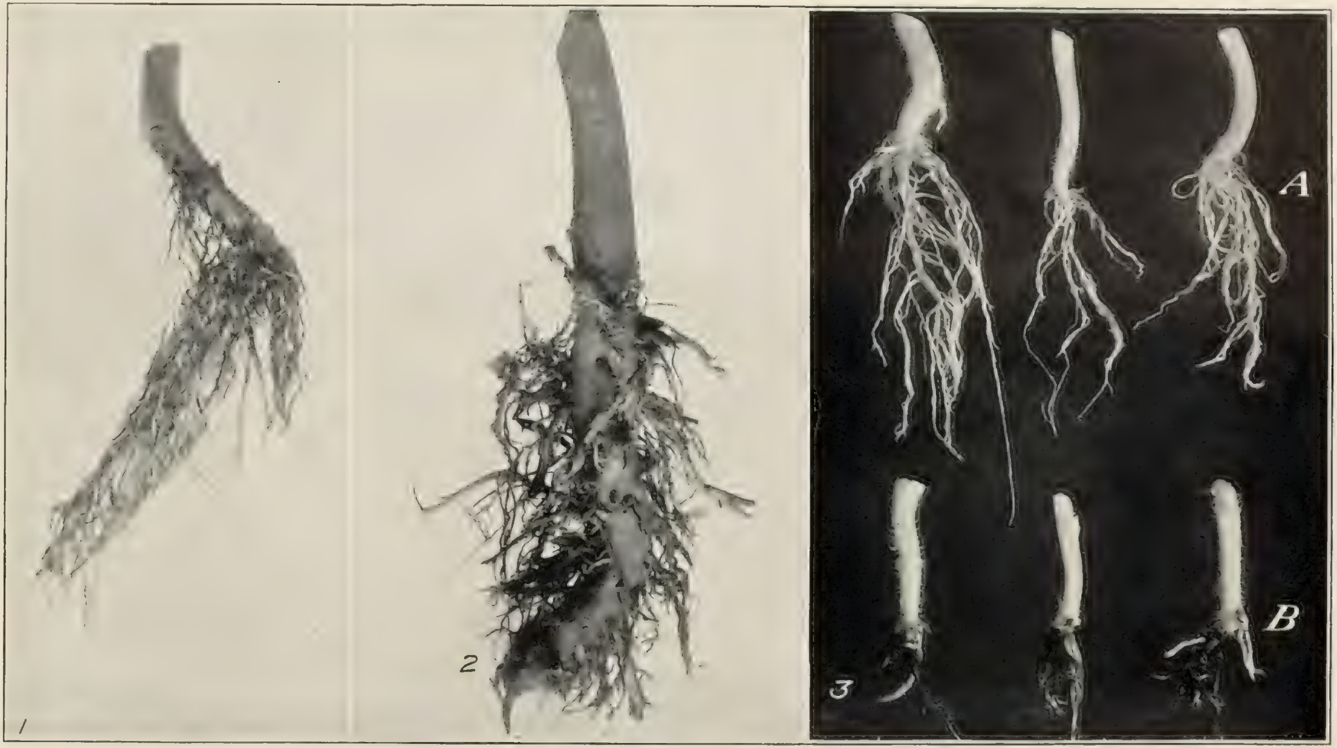
W. W. GILBERT AND J F BREWER

MICROSCOPIC CHARACTERS OF THE ROOT-ROT FUNGUS IN VARIOUS STAGES.



TWO DISHES CONTAINING GROWING TOBACCO SEEDLINGS, AFFORDING A DEMONSTRATION OF THE PARASITISM OF THIELAVIA.

A, Inoculated; *B*, not inoculated.



TOBACCO PLANTS AFFECTED WITH ROOT-ROT.

Fig. 1.—Plants inoculated at two months. Fig. 2.—Diseased root from field. Fig. 3.—Seedlings from soil inoculated with Thielavia: *A*, sterilized with formalin (1 to 200), and, *B*, untreated.

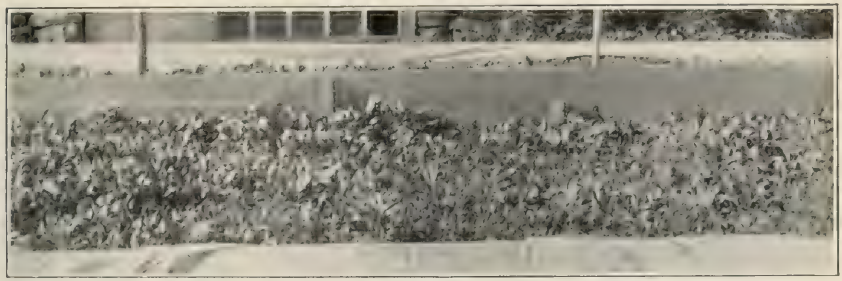


FIG. 1.—A TOBACCO BED BADLY DISEASED WITH ROOT-ROT.

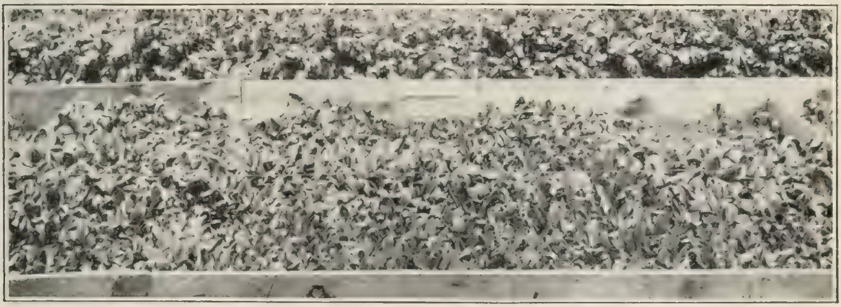


FIG. 2.—TOBACCO PLANTS IN THE SAME BED SHOWN IN FIGURE 1 AFTER IT HAD BEEN STERILIZED WITH STEAM.

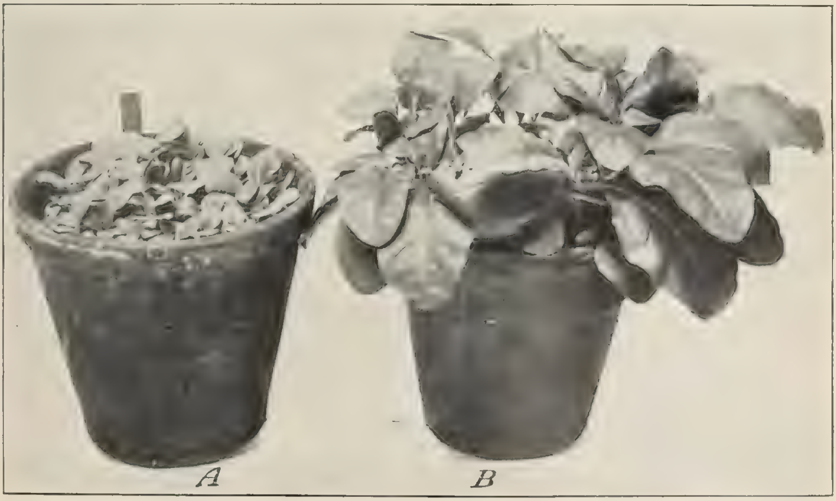


FIG. 3.—SEEDLINGS GROWN IN DISEASED SOIL.

A, Not sterilized; *B*, steam sterilized.

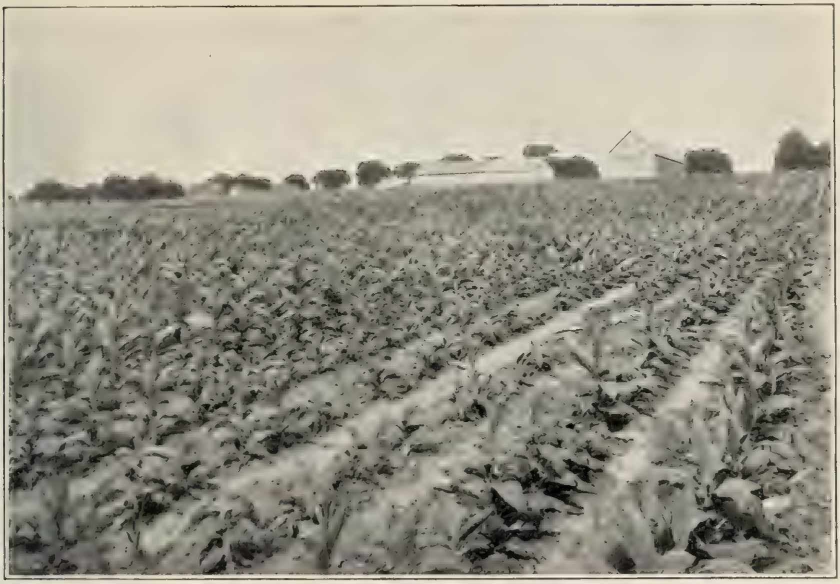


FIG. 1.—A DISEASED SPOT IN A TOBACCO FIELD.

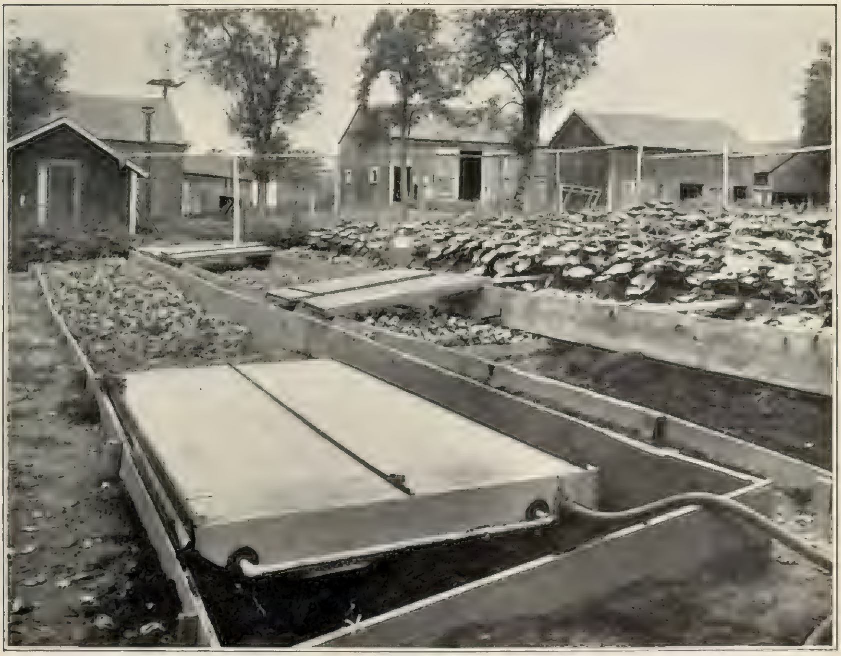


FIG. 2.—A TOBACCO BED BEING STERILIZED WITH STEAM BY THE INVERTED-PAN METHOD.

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B. T. GALLOWAY, *Chief of Bureau.*

LOCAL ADJUSTMENT OF COTTON VARIETIES.

BY

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BIONOMIST, BUREAU OF PLANT INDUSTRY.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 25, 1909.

Sir: I have the honor to transmit herewith a paper entitled "Local Adjustment of Cotton Varieties," by Mr. O. F. Cook, and recommend its publication as Bulletin No. 159 of the special series of the Bureau of Plant Industry.

By maintaining local adjustment, crops can be improved, even without improving varieties. That new conditions and unfavorable seasons may render varieties less uniform has been known in horticultural plants. The present study shows that such facts have a practical application in field crops and that they must be taken into account in problems of heredity and breeding.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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B. P. I.—490.

LOCAL ADJUSTMENT OF COTTON VARIETIES.

INTRODUCTION.

A variety of cotton planted in a new place usually behaves in an abnormal manner. The abnormal behavior is generally proportional to the change of conditions, though different varieties respond in different ways to the same set of new conditions. Central American varieties of cotton grown for the first time in Texas usually show a definite alteration of the habits of growth and a notable decline in fertility. To lead an imported variety back to the regular expression of its normal characteristics and productiveness is called acclimatization. Varieties that do not remain entirely sterile under the new conditions can usually be brought back to their normal characteristics and fertility in from three to five generations.

When our Upland varieties of cotton are carried from one part of the cotton belt to another, or otherwise placed under new conditions, they also show deviations from their normal characteristics. Though the changes in the characters of the plants are very much less than with the imported varieties, they often have a serious effect upon the quantity and quality of the crop. To avoid this kind of deterioration, a process of local adjustment is required, analogous to acclimatization, but more readily accomplished.

Though local adjustment, viewed from the biological standpoint, is a much less striking phenomenon than acclimatization, it has a much greater and more general agricultural importance. The difficulties which have to be surmounted by acclimatization are met only in the introduction of new varieties from remote regions. It is only when we consider the advantage that might come from the successful introduction of better types of plants or of plants better adapted to special conditions or uses that acclimatization becomes a subject of general interest.

Local adjustment is of practical importance in quite a different way. The failure to make use of local adjustment does not result in a rare or occasional expense, but causes a very general and regular loss to the cotton industry, a loss that would be represented by enormous annual totals if the facts could be definitely known. Even at a low estimate of 10 per cent, which is certainly far below the average, the increased crop which could be secured by attention to the facts of local adjustment would have an annual value of $60,000,000. With very slight expense of time and effort in the selection of seed for local adjustment, and with no other change, either in varieties, lands, or methods of culture, it would be possible to add 10 per cent to our cotton crop or to reduce the acreage and expense of production by a similar amount without reduction of the yield.

Our experiments in Texas lead us to believe that the losses occasioned by the boll weevil can be well-nigh made good if the advantage of local adjustment be added to those that can be gained by using better varieties and better methods of culture. This indication may not apply in the more humid districts in the eastern part of the State, but appears to have ample warrant in the western and southern parts, where our experiments have been made. Rainy weather during the growing season favors the rapid multiplication of the weevils and may enable them to ruin the crop in wet seasons, even in regions that usually escape serious injury, but these more severe attacks are usually confined to rather limited areas and are not likely to occur every year, whereas a continuous advantage can be gained from local adjustment. To maintain uniformity by local adjustment is especially important in weevil-infested regions as a means of securing the earliest and most uniform development of the plants, and thus allow the largest possible crop to be set before the weevils become destructively abundant.

The reader may be unwilling to believe that so simple an expedient as local adjustment should have been so long neglected if it has any such importance as claimed. The fact that notably increased yields of cotton, as of other crops, can be secured by selection of seed has not remained unknown, but the reasons why such improvements occur are not fully understood. The benefits that can be obtained at once from local adjustment have been confused with the much slower and more gradual changes that accompany the selection of carefully tested, exceptionally superior individuals. The emphasis that is often laid on special skill, precaution, and persistence as necessary qualifications for the successful breeder has tended to keep the average farmer from undertaking to improve his own crops by selection.

Local adjustment can be viewed as something quite apart from breeding for improvement; its object is merely to keep a variety as it is, instead of allowing it to deteriorate by becoming diversified as a result of changes of external conditions or of unfavorable seasons. No matter how superior a part of the plants may be it is certain that the highest yields can not be secured unless all of the plants are kept as near as possible to the standards of the variety. The better the variety is the more serious the loss that comes from neglect of local adjustment, for the greater is the probability that every change from the characters of the variety will be in the direction of inferiority.

To know that yields can be increased by selection is a useful fact, but it is still better to have an adequate reason for it. A fact illuminated by reasons, so that the mind can follow and understand its relations, is what we call a scientific fact; a fact without a reason is called an empirical fact. It is often possible to utilize a fact without understanding it, but facts that we can understand are still more likely to be utilized. The art of farming includes large numbers of empirical facts that have come down to us as customs and traditions, but we take up very slowly and unwillingly any new method or operation unless a positive necessity or a very definite advantage can be shown. As long as the issue is not clear or the results are not so definite and invariable as to leave no room for doubt, the new requirement is likely to be avoided.

As soon as the farmer appreciates the fact that lessened uniformity is one of the chief causes of deterioration in cotton varieties he will also be convinced that the selection of his own seed is just as essential and necessary a part of his farm operations as the planting, cultivation, and harvesting of his crop.

It may be that local adjustment has not the same importance in other crops as in cotton, but here, at least, it is evident that the selection of seed for local adjustment is quite as important as any other work with the crop. A small amount of labor has a large effect on the final returns. Except for the picking of the larger crop it takes no more work to raise a well-adjusted strain of cotton than one that is deficient in adjustment. The selection of seed for purposes of local adjustment requires a certain degree of care and skill, but nothing beyond the ability to be found in the average farmer's family. The wife or the children may prove more capable than the farmer himself, and their assistance need not be refused, since the work is easy and enjoyable.

In thus pointing out the practical advantages that are to be expected from local adjustment, there is no intention to imply that the results will always be the same as those that have appeared in our experiments. The factors that are involved in local adjustment are highly variable, in the very nature of the case, since they have direct relation to variable external conditions. The details of the experiments given in this report are introduced as illustrations of the different ways that the factors of local adjustment have appeared to work, not as adequate demonstrations of local adjustment, even for the varieties and the conditions under which our experiments have been made. If the facts of diversity and local adjustment were rare or exceptional there might be need to establish them by more elaborate evidence, but they are readily accessible to observation, if not already familiar to students of cotton. A more general recognition of their practical importance may be expected to secure for them the careful attention of experimenters.

DIVERSITY AS A NEW-PLACE EFFECT.

When a high-grade variety of cotton or of any other cultivated plant is grown in a new place and fails to give as good results as in its home locality, it is usual to draw the conclusion that the conditions of climate or soil of the new locality are unfavorable to the variety. Even when no unfavorable factors are known, it is still usual to trust to the assumption that some peculiarity of the variety renders it less suited to the new surroundings than to the old. It does not surprise us that a carefully selected variety fails to appear to the same advantage outside of the region in which it was developed. The selection of plants for purposes of agricultural improvement must always have reference to the external conditions under which the selection is made. Nevertheless, it is as distinctly a mistake to ascribe too much to the special adaptations of varieties as to leave this factor out of account. We must learn what we can regarding the nature of the changes that take place under new conditions, and of the possibility of avoiding them.

When a variety of Upland cotton planted in a new district fails to attain the standards of the variety, it is usually very easy to show that inferiority of the new conditions is not the only cause of the failure, or even the chief cause. Comparison of the individual plants with each other will soon make it evident that they are much more unlike among themselves than any reasonable supposition of inequality in the conditions would explain. Many individual plants are likely to be found which have not fallen below the previous standards of the variety.

The best of the plants, rather than the worst or the general average, represent the proper test of the possibilities of the variety under the new conditions. The unequal behavior of the plants will often be found to be a larger factor in the low general average than any definite limitation set by the external conditions. If the best plants are as good as in the home locality of the variety we may have an assurance that the new conditions are not in themselves directly and essentially unfavorable, for in that case none of the plants would be able to attain the fully developed characters of the type. The crop may be damaged as much by changes that arise in the plants as a result of new conditions as by factors that actually limit the growth of the plants, but the nature of the damage is different in the two cases.

The more carefully the matter is studied the more evident it becomes that the failures of many individual plants to show the true characteristics of their variety when grown in a new place are connected with differences in the plants themselves and are not directly connected or proportioned to the differences in the conditions occupied by the various individuals. The greater diversity shown among the members of the variety in the new place explains the apparent deterioration. To avoid this diversity and thus maintain a more general conformity to the normal characters of the type is the object of local adjustment.

External conditions that are actually unfavorable to the growth of the plants may be less conducive to undesirable new-place effects than conditions that are distinctly better for an acclimatized or locally adjusted stock of the same kind of plants. This was conspicuously shown in an experiment with imported types of Upland cotton at Falfurrias, Tex., in 1907. In the rows that ran out into drier and more sterile soil a large proportion of the smaller plants in the dry soil kept nearly the normal characteristics, whereas among the larger plants in the better soil only a few individuals remained small and normal. The few small plants in the moist soil and the few large plants in the dry soil showed that individual differences in the plants were able to fully counteract the differences in the conditions.

The inspection of even a few fields with such distinctions in mind is likely to convince any person who is at all familiar with such cotton that diversity among the plants themselves is a factor of practical importance in the diminution of crops and deterioration of varieties. Something in the way of special training or of natural aptitude may be required to give one a full appreciation of this diversity as a concrete, scientific fact, and to enable comparisons to be made between amounts of diversity that are present in different stocks of cotton or in different localities. Some persons appear to be as distinctly lacking in the necessary powers of perception of minor differences of form as others are of shades of color, but it is believed that most people will be able to recognize the forms of diversity that figure in the local adjustment of cotton varieties.

NEW-PLACE DIVERSITY DISTINCT FROM FLUCTUATING VARIATION.

The chief difficulty that has interfered with the recognition of the phenomena of diversity by scientific students and experimenters is not that they are not readily visible, but that they have been confused with other types of variation, such as the ordinary fluctuating differences, accommodative changes, direct effects of environment, and diversity due to hybridization.

Diversification under new conditions represents a fourth group of facts quite different from the other three and much more related to the phenomenon of mutation, as described by De Vries. The progeny of divergent plants may be expected to show fluctuating differences like the members of other varieties, and mutative changes may affect the same characters that are subject to accommodation, but such facts need not prevent the recognition of essential differences. That seedling plants are able to become more diverse among themselves when grown in a new place, even in the first season, and that these diversities have a relation to external conditions are facts not commonly recognized.

The recognition of these new-place diversities does not depend upon the systems of measurements that have been applied to fluctuating variations. Careful measurements of large numbers of plants or animals may lead to the recognition of differences that would not otherwise be detected, but in this case the differences are readily appreciable by direct observation. If the cotton plants that show diversity had to be detected by elaborate systems of measurements, local adjustment would be altogether impracticable. A considerable body of scientific workers would be needed for a whole season to give an adequate statistical account of the diversities of a single field of cotton. It may be obvious at a glance that the leaves of a plant are narrower than those of its neighbors, but many hours might be required to measure, record, and compute with proper care the data that are necessary for a mathematical determination of the actual differences of proportion that are responsible for the general impression. The leaves of the same cotton plant are so variable among themselves that a large number would need to be measured before general averages could be established.

And even after a statistical difference has been ascertained it might still convey a very inadequate idea of the diversities that figure in local adjustment. Mutative changes seldom appear to affect one character alone, and do not obey the law of regression established by Galton. Unlike the fluctuating variations which may be thought of as mere deviations from the same course or standard of heredity, mutative changes render the plants essentially different throughout, often quite as different as the members of distinct species, or even more so. Indeed, one of the serious objections to the idea of mutations as new species lies in the fact that the members of mutative varieties of domesticated plants are much more alike among themselves than are the members of wild species living under natural conditions.

To describe the mutative variations of our cotton varieties as new species would be a very formidable undertaking and may be left to those who believe that mutations are really species. The present report is intended only to call attention to the fact that such variations are of frequent occurrence in cotton, that their numbers are still further increased by changes of external conditions, even to the extent of injuring crops and causing varieties to deteriorate, and, finally, that these dangers are to be avoided by continued selection for local adjustment.

NEW-PLACE DIVERSITY DISTINCT FROM ACCOMMODATION TO EXTERNAL CONDITIONS.

Changes of characters that have definite relations to external conditions are usually called adaptations or accommodations. Writers on evolution and heredity have recorded many examples of plants and animals that show accommodations to different conditions. Among the most familiar instances are the amphibious members of the buttercup family that have ordinary rounded leaves when growing on land, and very narrow, finely divided leaves when growing in water. The same individual can be induced to change the form of its leaves by planting it in water or taking it back to dry land.

The larger, thinner leaves that the coffee plant produces in the shade will not endure exposure to the sun, so that shade-grown seedlings usually lose all their leaves when planted in open places. If the change is not too severe the plant is able to adapt itself to the new conditions by putting out smaller, narrower leaves of firmer texture able to endure exposure to the sun.

Similar changes occur in the stature and habits of growth of the cotton plant in response to differences of environment. In one locality every individual will be larger and have more numerous vegetative branches than any individual of the same variety as it grows in some other locality. In localities where the winds are strong some varieties develop stiffer stems that resist the wind, while others avoid the need of such resistance by assuming a prostrate habit of growth and sending their branches out along the ground. Two selections from the same stock of Mexican cotton showed the same habits of growth at Victoria, Tex., but at Del Rio one of these developed a stronger central stem than at Victoria, while the other became notably prostrate.

Our experiments with the acclimatization and local adjustment of cotton varieties have made it certain that there is another class of changes of characters, those that accompany changes of external conditions, and yet stand in no such direct relations with the external conditions as do the adaptive or accommodative changes. Though accommodative changes may often appear to make members of the same species unlike they are not thought of as rendering them more diverse or individually different. An accommodative change may be shared by all the plants with as much uniformity as any other feature.

Many of the changes of characters that occur in new places, instead of rendering the plants better fitted for the new conditions, render them less fitted. This is certainly true of the instances in which the plants that change their characters are rendered unproductive or completely sterile. A wild plant that behaved as many of our newly imported varieties of cotton have done would have no prospect of surviving. And yet several of the varieties that were nearly sterile in the earlier generations have returned to normal habits of growth and fertility after a few years of acclimatization.

Experience with these more profound changes that attend the process of acclimatization has made it easier to appreciate the nature of the diversity that necessitates the careful adjustment of varieties to local conditions, even in our United States Upland type of cotton, where the stage of acclimatization was long since passed.

Since many of the changes of characters that occur under new conditions obviously do not serve purposes of adaptation, and often result in wide individual differences, even under the same external conditions, it is evident that they ought not to be considered as due to accommodative changes of characters, but rather as resulting from loss or disturbance of adjustments of heredity previously established by selection or by mutation. We may inquire, therefore, into the nature of the adjustment of characters that is disturbed when a variety is planted in a new place, to gain an indication of the possibility of restoring the adjustment and regaining a uniform expression of characters under the new conditions.

The fact that the diversity that appears under a new environment is not the same as a regularly established accommodation does not compel us to deny that new-place diversity may have an adaptive value, since it allows a species to make tests, as it were, of the many forms that its members are able to assume. The forms that prove to be best adapted to the conditions are most likely to survive, and the species may thus secure a better footing than if compelled to keep to a form less suited to the new surroundings. Thus we may consider new-place variations as experiments in accommodation or as affording the materials from which the more definitely accommodative characters may be developed.

It is often assumed that natural selection must have the same tendency as artificial selection to reduce the members of a stock to a condition of uniformity in their environmental relations. Natural selection, however, is a composite of many factors often completely opposite. A dry season that gives the plants a selection for drought resistance may be followed by a wet year that tests their progeny for ability to endure excessive moisture. The advantage would not lie with the lines of descent that specialized exclusively on drought resistance or on flood resistance, but with those that kept the two contrasted qualities represented in the family, either by producing progeny of two kinds or by combining the two qualities in the same individuals. Even though all the drought-resistant individuals were wiped out in a particularly wet season the drought-resistant characteristic need not be lost to the species, but might continue undiminished in transmission.

Much emphasis has been placed upon natural selection as an agency for producing greater uniformity through the weeding out of the lines of descent that yield weak or defective individuals, but this is not a reason for holding that the survivors are made more uniform among themselves by natural selection. The tendency is rather to preserve and combine all the different characters that give increased abilities or powers of resistance.[a]

RELATION OF NEW-PLACE DIVERSITIES TO HEREDITY.

The agricultural superiority of a carefully selected variety depends largely upon the greater uniformity that follows persistent selection. Wild or unimproved types differ from our high-grade varieties not so much in a complete lack of the desirable characters as in a failure to produce the desirable characters with sufficient regularity. Success in the art of breeding is largely a matter of securing uniform progeny from desirable parents.

With seed-propagated field crops like cotton, uniformity of characters is established by persistent selection. The breeder reduces and eliminates the individual diversity that renders a wild or unimproved stock inferior for agricultural purposes to stocks that have been improved by selection. By rejecting all the individuals that express other than the desired set of characters, much higher averages of the desirable features are secured by the breeder. A still more effective method is to preserve only those individuals that bring the desired characters to the highest degree of expression.

It is often supposed that a sufficiently thorough course of selection is able to completely eliminate the undesirable diversity of characters from a domesticated variety, but it is very doubtful whether the ancestral diversity is ever destroyed, in the sense of ceasing to be transmitted. With the most favorable conditions and in varieties that have been bred with the utmost care, individual examples of diversity continue to appear more or less frequently. No complete uniformity is ever attained. Even in vegetative varieties of plants grown only from cuttings or in varieties of wheat that are regularly self-fertilized, variant individuals are still to be found. That the original diversity of characters has continued to be transmitted, even in these most uniform types, is also shown when hybrids are made, and a large number of the ancestral diversities reappear at the same time and under the same external conditions.

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[a] For a better appreciation of these tendencies of natural selection to maintain diversity in species and preserve the extremes of expression of environmental characters, the writer is indebted to Mr. A. F. Woods. The point has an evolutionary bearing, since it suggests a way in which natural selection may assist evolution by preserving diverse tendencies among the members of the same species and thus allowing the most advantageous combinations to be built up.

These considerations make it quite unnecessary to suppose that the diversities that crop out among the members of a variety in a new place are impressed upon the plants by the external conditions. We are fully warranted in believing that much of the diversity represents inherent transmitted characters which have been able to come back into expression because the change of conditions has disturbed the previous adjustments that selection had established. It is not necessary to suppose that the diversities shown in the new place are different in any essential respect from the relatively rare individual sports or mutations that appear in the varieties, even under accustomed conditions. The chief difference is that the new conditions call forth many of these variations at the same time. Instead of sporadic mutations of single individuals, we often obtain in a new place a simultaneous promiscuous mutation of many individuals, sometimes of all the individuals, each becoming definitely unlike any of its neighbors, even when large numbers are carefully compared.

Viewed in this way it is possible to understand what our experiments show to be a fact, that even a relatively large disturbance of heredity shown by a variety of cotton planted in a new locality does not afford a sure indication that the conditions are unfavorable. And where the conditions are not unfavorable it ought not to be considered impossible to restore the previous uniformity of the stock by renewing the process of selection that established the uniformity in the first place. Experiments have also shown that such readjustments are readily established, at least in the cotton varieties with which experiments have been made.

A COMPARISON OF DIVERSITY IN TWO LOCALITIES.

To gain definite information regarding the nature and extent of the diversity which is aroused by planting a variety of cotton under slightly different conditions, a careful comparison was made between two fields of Triumph cotton—one at Lockhart, Tex., the other at Kerrville, Tex., in the season of 1907. Both of these localities are in the west-central part of Texas. Lockhart lies 63 miles northeast of

San Antonio, at an altitude of about 500 feet, while Kerrville is 71 miles to the northwest, with an altitude of about 1,700 feet. The soil conditions as far as they affect the size of the plants do not appear to be seriously different.

The Triumph cotton is known to breeders as one of the most regularly uniform varieties. It was originated at Lockhart by Mr. Alexander Mebane, and has been carefully selected by him for a considerable series of years. It would be difficult to imagine better examples of uniformity in a variety of seed-propagated plants than are afforded by Mr. Mebane's fields of Triumph cotton. A careful inspection of about 50 acres of Mr. Mebane's cotton resulted in finding only three plants that appeared to be definitely different from their fellows.

Immediately after this test of diversity had been applied at Lockhart, and with the uniformity of the Triumph cotton at that place as a basis of comparison, a similar study was made of a much smaller field of cotton raised at Kerrville, Tex., from seed grown by Mr. Mebane at Lockhart. The difference in diversity between the two places was very striking. Adjacent individual plants were often obviously unlike, and a considerable percentage of the plants could be reckoned as showing distinct departures from the Triumph type.

If the facts were to be interpreted in the usual manner, any observer would have felt fully justified in saying that the conditions at Kerrville were much less favorable than at Lockhart, for many of the plants were distinctly inferior in size and fertility and many of the smaller individuals remained quite sterile. It would be very natural, of course, to use these small and unproductive plants as examples of unfavorable conditions, but other facts showed that this explanation was insufficient. In addition to many small plants that remained completely sterile, there were numerous others that had unusually small bolls, different from those of the Triumph cotton. Other peculiarities of habits of growth rendered these small-bolled plants closely similar to inferior plants that appear among our Central American cottons during acclimatization. Moreover, these peculiar plants with the small bolls were notably later than those that kept the normal Triumph characteristics, so that no ripe seed could be obtained.

In addition to the small-bolled plants there were many other individuals that showed less violent departures from the normal Triumph characters, but still very definite differences. The nature of these differences is indicated in the following notes that were made on a series of selections of variant plants, in order to test the inheritance of their divergent characters:

(1) Plant tall; bolls rather varied in size and shape, broad but long pointed, sometimes with groove in the middle of the carpel at

the tip; lint abundant, long. The next plant in the row, apparently normal, had lint only half as long.

(2) Plant very open; basal internodes of the branches very long; lint long; seed smooth.

(3) A very small, low, short-jointed plant, with two branches at each node, possibly a result of injury to the main stem.

(4) Rather larger than its neighbors. Branches all rather long, only one from a node; bolls rather large, all but one with five locks; seeds very large, smooth, with a light-brown ridge along one side.

(5) Plant vigorous; bolls large, not notably different from Triumph; seed rather small, greenish; lint very fine, silky, especially in one boll.

(6) Small plant, about 1 foot high, with light foliage; small bolls, rather narrow and pointed; fruiting branches very short, with only two or three internodes, three of the branches with only one leaf and a boll; lint fine, medium; seed small; bracts connate at base.

(7) Plant large and vigorous, notably more fertile than neighbors; branches long; lint very abundant and of good length; seed green, rather small.

(8) Plant medium, open, either not vigorous or very early and determinate. Most of the leaves already moribund (determinate). Leaves rather long pointed, but some entire without lobes; bolls small, narrow, pointed, some with only three locks, others with four and five; seed smooth.

(9) A small, low, spreading, double-branched plant. Seed with short green fuzz in upper part and long white fuzz below.

(10) A very large plant with long, simple, and double branches and long basal internodes; large Triumph-like bolls; seed very smooth with a small brown tuft at base; lint of medium length, fine.

(11) A large, open plant with long branches, ripening more bolls to date than any of its neighbors, perhaps also determinate; lint not long, but abundant; numerous aborted seeds with lint developed.

(12) A small, open plant with four rather long slender vegetative branches; fertile branches of one or two internodes; only one boll, very small.

(13) A vigorous, long-branched plant; very hairy, notably more so than any of its neighbors, on the stalks, branches, petioles, peduncles, and bracts, and on the veins of the lower surface of the leaves.

(14) Plant vigorous, but not oversized; leaves rather gray-green with long, rather narrow lobes; very short primary branches pushing out at all the nodes and giving the main stem a leafy appearance;

stems unusually hairy, but somewhat less than in the preceding; bolls small; lint short; more fertile than the neighboring plants.

It became evident that the diversity alone would account for a considerable diminution of the crop at Kerrville without resorting to the idea that the conditions were really less favorable than at Lockhart. Many individual plants that retained their normal characters were also as fertile as at Lockhart. A further test of the possibilities of normal behavior for the Triumph cotton under the Kerrville conditions was afforded by the adjacent experiments with cotton of the same variety which was being grown for the second time at Kerrville. In this there was no such amount of diversity and no such obvious disparity of yield among the individual plants as in the plot grown from the seed newly brought in from Lockhart.

The fact that our Upland varieties of cotton are not uniform, but usually show a large amount of diversity among the individual plants, has been generally remarked by breeders and experimenters. Stress has usually been laid upon the idea that breeders of varieties have not been sufficiently careful and persistent in selection or that there has been a relapse to diversity through admixture of seed in ginning or through cross-fertilization with other varieties in the field. The following conclusions were reached by Dr. J. F. Duggar, director of the Alabama Agricultural Experiment Station, where a long series of tests of cotton varieties has been made:

> Man has done quite as much as nature to increase the confusion as to the varieties of American Upland cotton. The chief difficulty that has been encountered in the attempt to describe and classify cottons grown at Auburn under several hundred different names has been the absence of uniformity among the plants of a single variety. While this variability is partly due to natural agencies, it is also largely due to the failure of growers to avoid the mechanical admixture of the seed of other varieties, which so easily occurs at public gins. Worse still, in the case of many, perhaps most, of the so-called varieties, there has been no long period of selection through successive years with a view to fixing a uniform type.[a]

But whatever the causes of diversity in other varieties, it is evident in the case of the Triumph cotton that a variety which has been brought to a notable degree of uniformity in its home locality may at once become diverse when transferred to another district, at no great distance, and even under conditions that are not really unfavorable to the variety, as shown by the readiness with which it returns to uniformity after selection for local adjustment.

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[a] Descriptions and Classification of Varieties of American Upland Cotton. Bulletin 140, Alabama Agricultural Experiment Station, July, 1907, p. 24

TESTS OF INHERITANCE OF DIVERGENT CHARACTERS.

As a further means of determining the nature of the differences that appeared in the Triumph variety as a result of the transfer from Lockhart to Kerrville, seed was saved separately from fourteen plants that seemed to show the most definite divergence from the varietal characters of the Triumph cotton. The seeds of these individual selections were planted at Kerrville in 1908, but a late frost killed most of the seedlings, in some cases all. Nevertheless, enough of the plants remained to make it very evident that some of the divergent characters were definitely inherited.

Plants noted as having branches with unusually long basal internodes and very open habits of growth (Selection No. 2) gave progeny of the same kind, very definitely contrasted with the progeny of low, compact, short-jointed plants, which showed a similar fidelity to parental characteristics. Some of the tall plants were noted by Mr. Rowland M. Meade as having the leaves and branches arranged in a one-third spiral instead of the usual three-eighths spiral, which would account for their more open form.

A plant (No. 9), selected because of a pronounced tendency to produce two branches from each node of the main stem, gave progeny in which this character was similarly pronounced, much as in the weevil-resistant Kekchi cotton from Guatemala. If this peculiarity had not been noted in the first generation, the second generation might have been suspected of being a Kekchi hybrid.

Another case of the same kind was found in a plant selected for unusual hairiness of leaves and stems, giving a distinct suggestion of approach to the more hairy Central American types of cotton, which was definitely repeated in the second generation (Selection No. 13). Another mutation with the hairy characteristic definitely expressed and as definitely inherited also had leaves with somewhat narrower lobes than in Triumph cotton and more commonly 5-lobed, as often happens in the Kekchi cotton. It also showed in both generations a distinct tendency to develop a short primary branch at each node, giving the main stalk an unusually leafy appearance (Selection No. 14).

Many other examples might be given in which mutations of our Upland cottons showed interesting resemblances to the Central American Upland types, as though to indicate a common ancestry for the whole Upland series. One of the most frequent approximations of this kind occurs in small, broadly branching, tree-shaped plants with very small bolls, as already noted in the general account of the Triumph mutations at Kerrville. From the only small-bolled plant which afforded ripe seed only one plant was raised, and this had notably small bolls, though it retained the Triumph character of short fruiting branches, as the parent plant had also done.[a]

Peculiarities of the lint and seeds were also definitely inherited in the progeny of the Triumph mutations, though not with complete regularity. Notably long-linted parents gave notably long-linted progeny, short-linted parents short-linted progeny. The smooth-seeded character was retained in several instances, though not in all, while the tendency to a green color in the fuzz of the seeds was less in the second generation than in the first.

None of these mutations of Triumph at Kerrville were as conspicuously different from the parent stock as a plant that was pointed out to us by Mr. Mebane in one of his Triumph fields at Lockhart in 1906. This individual was about twice as tall as its normal Triumph neighbors and large in proportion. Its vigorous upright habit of growth and its foliage, of a somewhat lighter, fresher green, rendered it quite conspicuous. The bolls were as large as those of the Triumph variety, but the plant seemed much less fertile than the parent stock. A few seeds that happened to be ripe were saved, not only to test the inheritance of the variation, but to learn whether its fertility would be increased in subsequent generations. Six plants were raised from these seeds at Victoria, Tex., in 1907, all closely similar to each other and to the parent plant. The progeny of 1908 still kept closely to the parent form, but a report from Mr. John H. Kinsler indicates that the fertility is distinctly increased in the third generation.

Better fortune attended another experiment of the same kind at San Antonio. A similar series of selections of divergent plants was made in the season of 1907 in a plot of King cotton. Seven plants which seemed to show the most definite individual peculiarities were selected, their peculiarities noted, and their seed saved separately to see whether the same peculiarities reappeared in the progeny. The nature of the differences manifested in the selected individuals and the extent to which they appeared in the progeny can best be shown by following the original notes made at San Antonio in 1907 and 1908.

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[a] A very striking instance of approximation to the Kekchi cotton in a mutation of an Upland variety was observed by Mr. F. J. Tyler at Auburn, Ala., in 1907, and described by him in a letter to Mr. F. L. Lewton, under date of October 15, as follows:

"It is a Guatemalan cotton mixed in with Sunflower long staple. Of course it is a mutation or reversion, but it could hardly be more like Kekchi or Pachon as they look when grown in Texas for the first time. It is a large, rounded bush filled with sterile limbs, very late, nearly as pubescent as Kekchi and has the little bracts at the sinuses of the involucre. It is just beginning to bloom, and there is no hope of obtaining seed, as frost may be expected in a couple of weeks. It doesn't resemble Sunflower in any way, but must be a Sunflower plant. In 1905 Professor Duggar selected some seed from the best plants of Sunflower, and the seed cotton was carefully ginned and put away until this spring, so the seed was two years old. They have never had any Guatemalan cotton seed here at the station. On each side of this plant in the same row are typical Sunflower plants with bolls mostly open. I have taken a couple of photographs of the plant."

The photographs fully confirm Mr. Tyler's statement of the very close similarity of this mutation to the newly introduced Kekchi cotton. The shape of the plant and its method of branching, as well as the shapes, positions, and texture of the leaves, appear indistinguishable from those of the Kekchi cotton.

Behavior of original stock.—As a basis of comparison of the behavior of the mutations another planting was made in 1908 from seed held over from the same stock in which the various mutations had appeared. This row grew next to the mutations and consisted of very uniform, rather low open plants about 2 to 2½ feet high. Only one plant seemed to differ in any definite way from the others. It had numerous sterile involucres consisting of only one or two bracts. There were also many simple leaves and a few with unusually narrow lobes.

Variant with strong basal limbs.—The plant selected in 1907 was unusually large for that season. It was about 30 inches tall, and was also more vigorous and leafy than the average. There were 3 long, strong, sterile basal limbs and 22 bolls, maturing late. The plants were notably larger and stronger than original King, and bore a distinctly larger crop of bolls.

The progeny of this plant in 1908 were very uniform among themselves and differed notably from the row of original King in their larger size, larger leaves, more compact habits of growth, and stronger development of basal limbs. They produced a larger crop of bolls and a more uniform quality of lint. They were also larger than the parent plant of 1907, but this was generally true in all kinds of cotton grown at San Antonio.

More detailed comparison with the original King row established the fact that there were several other differences that had not been noted in the individual selection of the previous year. The leaves had somewhat longer and more pointed lobes. The lint was notably superior to that of the original King row, being longer, more abundant, and more uniform. The lint was also superior to that of the other mutations, though most of these appeared better than the original King, perhaps because of a greater degree of uniformity.

Variant without basal limbs.—Selection of 1907 a plant of medium size (2 feet tall), with the main stalk naked at the base for 8 inches and no sterile basal branches. Leaves relatively few, with shallow lobes.

The progeny of 1908 showed a marked contrast with the preceding row, especially in the habits of growth. Instead of the more compact form and larger leaves, these plants were much more open and had fewer, smaller leaves. There was a general lack of sterile basal limbs, leaving the stalks naked for several inches above the ground. This peculiarity was even more obvious than the unusual development of such limbs in the preceding row. The greater luxuriance of the plants brought, as might have been expected, a greater tendency to produce basal limbs than in the parent plant of the year before. Such branches were present on several of the plants, but to no such extent as in any of the other rows. There could be no doubt that the form of branching was definitely inherited, following a definite variation in this character in the preceding year.

One plant appeared somewhat different from the others, in having more abundant, longer lint and a tall, erect habit, with short fruiting branches, most of them with only one boll. It also had two strong basal limbs, and developed many new vegetative shoots late in the season.

Variant with numerous primary limbs.—The plant selected in 1907 was next to the largest (30 inches tall). There were sterile basal branches, but a primary limb developed at nearly every node, along with a fertile branch, as in the Kekchi cotton of Guatemala.[a] Of the nodes 11 produced 2 branches each. Of the 17 bolls more than half were deformed and decayed before opening; only 1 perfect boll remained.

The progeny did not follow the parent in the lack of sterile basals, but there was a much stronger tendency than usual toward the development of primary limbs. This would naturally be accompanied by a smaller development of limbs in plants that were less vigorous, like those of last year. Sterile basal branches, or "limbs," come from internodes which do not produce fertile branches, because the limbs represent transformed fertile branches.

Compared with the preceding series this row of plants appeared quite low, rather spreading, very leafy, and compact. They were not quite as uniform as the more upright and taller plants of the preceding mutation. The bolls did not appear defective, showing that this feature was probably only accidental in the preceding year.

Variant with compact habit of growth.—Selection of 1907 a small, productive, early, large-bolled plant; 15 inches high; 18 bolls; no basal limbs.

The progeny of 1908 appeared not greatly unlike those of the next preceding series, but they averaged distinctly smaller and kept more uniformly to the low, compact, leafy form. Later in the season these differences appeared still more notable. Most of the plants appeared to have strong limbs, but in many cases these were found to arise from primary buds that had started late in the season, instead of being transformed fruiting branches, which usually form the "limbs" of our United States Upland cottons. Early in September this row showed a great abundance of strong new shoots, more than any of the preceding rows, which still appeared relatively dormant. This might be connected with the greater earliness noted in the parent plant. The bolls continued distinctly larger than in original King, but mostly because of larger seeds; the lint was only a little better.

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[a] In the Upland type of cotton the vegetative basal limbs (also called wood limbs) can usually be looked upon as modified fruiting branches since they arise from extra-axillary buds, as do all the fruiting branches. The axillary buds may not develop or may do so only late in the season, but axillary buds are always found to produce only vegetative limbs that do not produce fruit directly, but may give rise to a new series of fruiting branches.

Variant with entire leaves.—Selection of 1907, a sturdy plant, 14 inches high. No sterile "limbs," but 3 small primary branches, each from a node that also had a fertile secondary. Fertile branches beginning close to the ground. Bolls 21, larger than usual in King.

The progeny raised in 1908 appeared closely similar to those of the previous selection in the next row in size, habit, and general appearance. They differed, however, in the much greater frequency of entire leaves, though this feature had not been noted in the parent. The habits of branching were much as in the last row. Some of the plants had basal limbs formed from sterile secondaries, but many of the apparent limbs were true primaries. The lint averaged distinctly better than in the last selection and also better than in original King, but not as good as in the first mutation.

Variant with smooth seeds.—Selection of 1907, a large plant, 30 inches high, with 3 good-sized basal limbs and 21 average King bolls. Seeds smooth and black, except for a brown tuft at the beak.

Progeny of 1908, 30 plants—5 with smooth seeds, 8 with seeds nearly smooth, 10 intermediate, and 7 with fuzzy seeds. The habits of branching appeared to be quite as varied as the characters of the seeds. Axillary limbs were sometimes developed, though many plants had none, but had instead two or three large extra-axillary limbs. Several of the plants had no limbs except as some of the axillary buds had grown out into fresh shoots late in the season. This is distinctly different from the behavior of the other rows where mature limbs were found at many of the joints, along with the fruiting branches.

Variant with narrow leaves.—The plant selected in 1907 was nearly 3 feet high, twice as tall as any other plant in its row. It had 2 long, sterile basal branches and narrow-lobed leaves, varying from small, entire, and lanceolate to those that were distinctly okra-like, deeply cleft into 3 to 5 narrow lobes. There were 7 empty involucres, composed of 1 or 2 bracts, and 20 very small late bolls.

The progeny of 1908 consisted of 34 plants, with a general similarity to the parent in size, habits of growth, and other characters, but also with distinct differences among themselves. Sterile extra-axillary limbs and axillary limbs seemed to be indiscriminately developed; the primary limbs were often as large as the others. Some plants had no limbs developed, others no large primaries; many had both kinds of vegetative branches graded in size, the lower axillary limbs nearly as large as the extra-axillary limbs.

The forms of the leaves showed equally definite variation. Of the 34 plants 1 had leaves of an extreme okra type, 13 had leaves of intermediate form but still distinctly okra-like, and all were more deeply cut than in Egyptian cotton. Finally there were 20 plants with normal broad leaves. In spite of much diversity in the size and shape of the leaves of the individual plants this separation of the plants into groups appeared to be very definite. Three persons picked out independently the same 20 plants as belonging to the broad-leaved group, though some of them showed, on careful inspection, a prolongation of the lobes beyond anything found in the original King row.

The empty involucres of the parent plant were definitely represented by irregular formations of the bracts, especially on the narrow-leaved plants. Among the 20 broad-leaved plants several had involucres with only 2 bracts more or less distorted and unequal, though only 4 had completely sterile bracts. Among the okra-leaved plants aborted buds were much more common, though 4 of the 13 intermediate plants did not show them.

In addition to this series, many other mutative variations of King and Upland varieties have been tested, with the same general results. Some have proved remarkably constant from the first, while others show less constancy or readier response to admixture with the parent stocks. One of the cluster variations of King, which are of very frequent occurrence, was tested at San Antonio in 1907, the progeny of a very prolific single plant raised at Victoria in the preceding year. The progeny showed the cluster habit in a very definite manner and were as uniform and as fertile as any other row of King, with the possible exception of a San Antonio selection. A few of the plants seemed to have definite differences, one having the very small, late-maturing bolls that mark a not infrequent form of degenerative reversion in many Upland types. It was also noted that the plants at the ends of the row, those that had a better supply of water, showed the cluster habit more distinctly than other plants more stunted by drought.

DIVERSITY WITHOUT HYBRIDIZATION.

The relation of these diversities of the King cotton to change of conditions is not so definitely established as in the case of the Triumph, for there was no previous opportunity to observe the degree of uniformity attained by the King under its original conditions. The King is also much more inclined than the Triumph to show definite forms of diversity, often accompanied by the cluster habit or shortening of the branches. On the other hand, this more variable tendency of the King gives greater significance to the fact that the variations are definitely inherited and do not behave after the manner of hybrids, though it is usual to ascribe the diversity of King to careless breeding or to admixture of seed. The fact ought also to be taken into account that the King cotton originated in North Carolina and is the most northern variety now being planted in Texas. The fact that a native Texan variety as uniform as the Triumph is also subject to similar diversities ought to be taken into account in attempting to understand the behavior of King.

Numerous plantings from the same stock of King seed in Texas in different localities and different seasons have shown different degrees of diversity. The most extreme instance of diversity was in Guatemala, where a planting of King yielded only two or three individuals with the usual characters of the variety. The others were as distinctly diverse among themselves as they were different from the normal type. The diversity was conspicuously greater than in any other United States variety included in the experiment; in fact, it exceeded the diversities of all the other Upland varieties taken together. While none of our Texas plantings of King has given an equal display of diversity, they have given us numerous examples of the same kinds of differences in individual plants. Similar facts are reported by Dr. D. N. Shoemaker, who has had much experience with this variety in Texas.

The possibility that the peculiarities of the selected plants of King cotton were due to hybridization seems to be excluded by the notable uniformity with which the peculiarities were repeated in the offspring. Such uniformity in hybrids is quite unknown. If the plants selected in 1907 had been first-generation hybrids their offspring of 1908, representing the second generation, should have displayed a full range of the differences of their grandparents. Instead of this, the progeny of different selections are often strikingly uniform among themselves, though differing notably as groups.

Such facts do not permit us to doubt that the changes of characters aroused in a variety of cotton when grown in new localities are of the same nature as the relatively rare mutative variations or sports that may appear without transfers to new localities. With greater changes of external conditions there are larger possibilities of arousing diversity. The definite inheritance of these changed characters in the next generation shows that the deterioration of a variety through the diversity called forth by a transfer to new conditions is not spontaneously corrected, but must be eliminated by new selection.

A large proportion of the diverse characteristics are not those of other recognized varieties, but are such as to render the plants unsuited to agricultural purposes—characteristics that would never be preserved by selection in an agricultural variety. Thus the small-bolled, late-maturing plants which appeared in considerable numbers in the Triumph field at Kerrville, Tex., were quite unlike any of our Upland varieties of cotton, though they are very similar to the dwarf, depauperate forms that occur very frequently during the period of acclimatization of the Kekchi and other Central American relatives of our Upland cottons.

While such facts do not show that hybridization may not have taken place farther back in the history of a variety, they show that the possession of the diverse characteristics is not to be explained by the theory of hybridization alone; the existence and continued transmission of characters not regularly expressed in our agricultural varieties has to be recognized. To account for all diversities by hybridization is to assume that there was an original, ancestral condition of uniformity when all the members of the stock had one and the same set of characters, and that this ancestral set of characters would have remained uniform if no hybridization had occurred. As soon as we recognize that diversity, rather than uniformity, represents the original condition there is less necessity to resort to remote possibilities of hybridization when diversities appear.

The tendency of many different types of cotton to show repeated mutations of the same kind or in parallel directions is an interesting phenomenon that has already been recognized in other plants by Mr. W. W. Tracy, sr., of the Bureau of Plant Industry. Mr. Tracy's extensive acquaintance with many varieties of garden vegetables has convinced him that there are general tendencies to variation running through whole natural orders of plants quite independent of the characters that have been used as the basis of selection in developing useful varieties.

> The different plants of the same natural order tend to vary along parallel lines. Fruit of the variety of tomatoes known as Early Conqueror, those of the pepper known as Squash or Tomato-Shaped, and of the Scarlet-Fruited eggplant could be selected, which would be as much alike in form as fruits from a single plant of any one of them; and I have seen a "potato ball" of the same form. I have found fruits of squash, muskmelon, watermelon, and cucumber each having the peculiar forms and markings generally confined to one of the others. Thus, last year, I found a plant of watermelon whose

> fruit was distinctly warted, and in form would pass for a fairly typical one of Summer Crookneck squash. I have seen muskmelons as flat and deeply scalloped as a fair sample of White Bush Scalloped squash—squashes as well netted and distinctly ribbed as a Bay View muskmelon. And it is taste and usefulness rather than limitation of variant tendency which determines the common shapes of these vegetables. I believe that hybridization is often credited with variation which is due to this common variant tendency.
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> Thus, the Lima bean, originally a climbing plant, continued so for many years, during which time several distinct races were developed, but no dwarf form appeared; then, within three years, dwarf forms of all the different racial types appeared, and in several different places simultaneously. The sweet pea, cultivated for many years and closely watched by many enthusiasts, gave only climbing plants until 1892, when the "Cupids," or dwarf forms, appeared in at least three locations and different stocks and five individuals, and since then they have appeared in a great many different stocks and places, and often where there could not have been pollen influence to induce the sport. In most vegetables, if any new form, no matter how distinct from those commonly cultivated, appears in one stock and place, there is almost a certainty that practically identical variations will appear elsewhere. For instance, the Navy Blue sweet pea was a very new and distinct shade and appeared in the fields of two cultivators the same year, the only discernible difference in the two sports being that the seed of one had a greater tendency to skin-crack than that of the other. This tendency to sport into new forms developing in the species rather than in any particular stock is often the cause of much annoyance to seedsmen, two or more of them being accused of sending out a new form under different names, when each supposed that he had the only origination of that type.[a]

While the theory of hybridization does not enable us to explain these parallel tendencies of mutations, they are not in conflict with the idea of a persistent transmission of ancestral diversities. The occurrence of similar variations like the small-bolled cotton plants through a whole series of diverse varieties is itself a reason for believing that this characteristic is present in the ancestry of many different kinds of cotton. Vigilant selection is able to prevent the continued expression of this character in any of our improved varieties, but it does not appear that there is any way of preventing this characteristic from reappearing in occasional mutative variations. The small-bolled character in cotton may be compared to the red ears of corn that continue to appear even in our most carefully selected varieties, or to the black sheep that appear occasionally in the most careful pedigreed stocks that are known to have been bred for large numbers of generations without the preservation of a single black individual.

It is not necessary to suppose that all of the forms of diversity that appear without hybridization are in the nature of reversions or reappearances of characters of remote ancestors. Many of the peculiarities of mutations may be viewed as examples of the suppression of characters. Characters that continue to be transmitted may suddenly fail to come into expression. If the normal color of a plant or animal depends on the formation of a green or black pigment in the cells the failure to produce this pigment results in the formation of an albino. Large numbers of white varieties exist among animals, for in these organisms the pigment is not indispensable, but plants can not grow without their green pigments, or chlorophyll, unless they are parasites or saprophytes. Albino seedlings occur, as in the Voorhees Red variety of sweet corn, but never grow to maturity.[a] When albinism is limited to stripes or spots the plants may survive, as in ornamental varieties with variegated foliage.

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[a] Tracy, W. W., sr. Variant Tendency and Individual Prepotency in Garden Vegetables. Memoirs of the New York Horticultural Society, vol. 1, p. 76. 1902.

The process of leaf development requires a very fine adjustment of the processes of growth among the different kinds of cells that form the upper and lower surfaces. If these adjustments are disturbed the plants are unable to develop leaves with even surfaces, but produce leaves that are irregularly crumpled or swollen out between the veins (bullate). Such irregularities in the formation of leaves are a frequent characteristic of mutations in many different families of plants, as in cotton, coffee, tomatoes, and capsicum. They are also characteristic of many varieties of lettuce and cabbage.

It is likewise apparent that the symmetrical building up of regularly columnar internodes or joints of the stems of plants requires nice adjustments of the process of growth. If heredity becomes disturbed so that normally straight internodes are not formed, the stems of the plants are unable to maintain their usual upright position, but can only trail along the ground or droop. This trailing or drooping tendency, like the bullate leaves, is a frequent characteristic of mutations of plants that usually have upright habits of growth. Numerous instances of prostrate cotton plants have been observed, and the same tendency is shown among the variant forms in many other families of plants.

Internodes may also become abnormal by failure to develop to a normal length, as in our "cluster" and "limbless" varieties of cotton. Such varieties of cotton apparently correspond directly to the bush varieties of beans, squashes, and dwarf peas mentioned by Mr. Tracy, and afford another instance of a familiar form of mutative change that extends through many different families of plants. The shortening of the internodes in cotton is usually confined to the extra-axillary branches that bear the fruit, and does not affect the axillary vegetative branches which share the functions of the central stalk.

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[a] Halsted, B. D. Experiments in Crossing Sweet Corn. Bulletin 170, New Jersey Agricultural Experiment Station, p. 19. 1904.

INCREASED YIELDS FROM LOCAL ADJUSTMENT.

To ascertain the amount of injury to the crop that might come from these changes of characters under new conditions, as distinguished from really unfavorable factors of climate or soil, adjacent plantings were made of seed raised and selected in the new place in the previous year and of other seed from the same original stocks of seed held over from the same lots, from which the previous year's planting had been made. Very definite differences were found in such plantings, showing that the selection of seed from plants that do not show changes of characters in the first year secures more uniform progeny in the second year. It is easier to understand this if we recognize the fact that the planting of a variety in a new place is in the nature of a test of the stability of the characters of the different individuals under the new conditions. The fact that the changes of characters are definitely repeated is itself a reason for expecting that the plants that do not change their characters in the first year will also have less tendency to changes of characters in the second year, and this seems to be the fact, at least with the Triumph cotton and some other varieties that have been tested in the same series of experiments.

The differences between the first-year and second-year plantings at Kerrville in the season of 1907 were in every case in favor of the second-year planting over the first, though the advantage gained in some of the varieties was much greater than with others. The Hawkins variety showed 5 per cent, King 9, Cook's Improved 11, Triumph 18, Parker 26, and McCall 33. In the case of the Triumph the actual yield from the Kerrville-grown seed was 37 per cent in excess of the yield from seed of the same original lot planted for the first time, but the stand of the latter was not complete, so that the percentage had to be estimated. The average rate of increase favoring the Kerrville-grown seed was 16.4 per cent. It was also plain before the cotton was picked that the second-year rows were superior in the size and fertility of the plants, especially in the cases of the Triumph and Parker varieties. The rows contained about 50 plants each and yielded seed cotton in amounts of from 3 to 6 pounds. These rows were alternated in such a manner that no inequalities of conditions could be supposed to have unduly influenced the results. The second-year rows were better whether they were above or below the first-year rows on the gentle slope where this series of plantings was made.

The careful comparison of rows of plants grown close together gives the best opportunities of ascertaining their inherent differences. With cotton grown under field conditions it is impossible to protect large numbers of plants against inequalities of soil. In this experiment at Kerrville, for example, it was very evident that the comparison of larger plots would have given much more unequal results. The Triumph cotton in the row tests was distinctly superior to the Triumph cotton grown in the closely adjacent field planting on the land which would have been used if a system of large plots had been employed to test the yields on a more extensive scale. Even on the level prairies of Texas the texture and composition of the soil is often extremely irregular, and the plants often reveal the existence of serious differences not visible before. The experiments suggest that the most satisfactory way of making yield tests of cotton in Texas is to plant two kinds in repeated alternation so that the inequalities between rows of the same kind can be compared with those of rows of different kinds. The same standard, locally adjusted variety may be used as a basis of comparison for different tests, but only by growing it in each case with the variety to be tested. Such yield tests ought to be made quite apart from breeding experiments, for the amount of cross-fertilization is likely to be very large.

It was noticed by Mr. F. L. Lewton in 1906 that the Hawkins and McCall varieties succeeded much better at Kerrville than in any of the other points in Texas where experiments were made. This fact may indicate that the Kerrville conditions were more similar than those of other localities to the home of these varieties in Georgia and South Carolina. Normal behavior of a variety in a new place means that the gain from local adjustment would be small, as proved to be the case with the Hawkins variety with respect to the yield, though the lint was distinctly better in the second generation at Kerrville.

A fairly satisfactory measure of the yield can be obtained by counting the numbers of bolls on the plants, without waiting for the actual picking of the cotton. First-year plants at Del Rio, Tex., showed on September 8, 1908, an average of 63 bolls per plant, while second-year plants at the same place had an average of 88 bolls. The counting of the bolls before they are ripe may not be a safe index of the crop, for the plants are often unable to ripen all the bolls that are set, but there is no obvious objection to the use of the number of bolls as a measure of the tendency to fertility from the standpoint of local adjustment.

OTHER TESTS OF LOCAL ADJUSTMENT.

In addition to the decrease of diversity and the increase of yield, several other standards for judging the progress of a variety toward local adjustment have been suggested by facts observed in these experiments.

While the yield is the most important test of local adjustment, it has not proved very convenient in connection with our experiments, because of the necessity in most places of making two or more pickings if all of the cotton is to be secured. Some varieties are likely to lose much more cotton than others if the crop is allowed to stand too long before it is gathered, and even in the same variety the earlier ripening of a locally adjusted row might result in an apparent lessening of the crop if stormy weather "scattered" some of the lint from the earliest bolls.

IMPROVED QUALITY OF FIBER.

The effect of local adjustment on the quality of the fiber is sometimes quite as striking as the general superiority of the plants in uniformity and yield. In the Kerrville experiments, where the increased yields were obtained from the locally adjusted rows, there was also a very distinct gain in the quality of the fiber. The method followed in judging of this improvement was to compare each plant of a row grown from Kerrville seed with its nearest neighbor in a row grown from the same original stock of seed held over for such experiments.

In some of the varieties the differences between the rows that represented first and second plantings of exactly the same stock were very striking, almost all the plants of the second-year rows showing better lint than those of the first-year rows. This was true particularly in the King, McCall, and Hawkins varieties, but in the Parker rows there was so little difference in the quality of the lint that the superiority of the second-year row appeared doubtful. In the McCall and Hawkins rows it was noticed that the plants in which the cluster habit was most pronounced never had long and abundant lint. On the other hand, such plants were often distinctly inferior, with only short and sparse lint.

INCREASED EARLINESS.

Increased earliness is an important factor in its bearing upon the yield to be obtained in regions infested with the boll weevil. It is quite possible that the larger yields of locally adjusted varieties at Kerrville were due, at least in part, to greater earliness, which allowed them to mature and to set more bolls before the boll weevil became destructively numerous. It is possible, however, to test the question of earliness apart from the question of yield by observing the times when the plants begin to flower or the bolls begin to open. Countings were made at Del Rio, Tex., in 1907, of the numbers of open bolls on first and second year plantings as a means of determining whether there had been a gain in earliness in maturity of bolls. Though the conditions at Del Rio were distinctly less favorable than at Kerrville for the display of local adjustment differences, the second-year rows showed larger proportions of open bolls at the date of our visit, September 30.

In the King variety a first-year row of 22 plants showed an average of 11.6 open bolls to the plant, while a row of 26 second-year plants gave an average of 12.8 open bolls. In the Hawkins variety 21 first-year plants had an average of 5.8 open bolls, while in the second-year row the average was 6.9. In the Parker variety the average for 25 first-year plants was 9.2 open bolls, while for 22 second-year plants the average was 11.1. In the first-year Triumph row only 8 plants had survived, but these gave a higher average, 9.37, of open bolls than 16 second-year plants, whose average was 6.06. In this case it appeared that unfavorable conditions had not only reduced the numbers of the plants and stunted their growth, but had also brought about a premature opening of the bolls on some of the plants that remained. Two of the first-year plants had 16 and 17 open bolls, respectively whereas the two highest plants of the second-year series had only 15 and 16 bolls. Both these rows of Triumph were very much inferior to a third row, representing a selection made at Victoria in the preceding year, which showed at the same date an average of 15.75 open bolls per plant. In the season of 1908 countings of first-year Parker plants at Del Rio showed an average of 8.8 open bolls, while an adjoining second-year row gave an average of 13.5.

For the benefit of those who may wish to make special selections for earliness in view of the advantage of early cotton in avoiding injury from the boll weevil, it may be well to notice the fact that there are several different factors of earliness that have different values in relation to the boll weevil. Early opening of flowers or of ripe bolls is not the form of earliness that is most needed as a protection against the boll weevil. The essential factor is the early setting of the bolls and prompt development to mature size, beyond the danger of weevil injury. Experiments with Central American varieties of cotton have shown that there are great differences in the readiness with which the different types open their bolls. In some varieties the bolls are opened as soon as they are mature, while in others the mature bolls may be held without any apparent change for a considerable period without opening. Some of the East Indian varieties of cotton do not open their bolls, the cotton being shelled out by hand after the bolls have been gathered. After a boll has passed the period of susceptibility to weevil injury there is no particular advantage in having it open early. The cotton of very early bolls is likely to be lost or damaged unless the number of pickings is increased.

The influence of local adjustment upon earliness is increased by the fact that the number of bolls that can be produced early in the season is directly dependent on the method of branching followed by the plant. The main stalk of the cotton plant produces two distinct kinds of branches, the fertile branches that bear the bolls and the vegetative branches that produce other fertile branches, but no bolls. If the young plants begin the formation of vegetative branches instead of fertile branches there is a definite postponement of fruiting, for no flower buds can be set until the fertile branches are formed. The study of the new-place diversities shows that changes in the methods of branching are one of the most frequent forms of variation.

LARGER BOLLS.

Progressive increases in the sizes of the bolls have been found by Mr. F. L. Lewton in successive plantings of cotton representing different generations of the same original stock in the same locality. In the Parker cotton raised at Winfield, Kans., in 1908, a ten-boll sample of seed cotton produced by a first planting weighed 55 grams, the ten bolls representing the second season at Winfield weighed 65.8 grams, while ten of the third season weighed 72.9 grams. The Hawkins variety showed 58.8 grams for the ten-boll sample of the first season, 53.8 for the second, and 61 for the third. In the Triumph and McCall varieties it was possible to compare the bolls only for the second and third seasons, but in both cases there seemed to be a distinct increase, in the Triumph from 95.6 to 99.2, and in the McCall, 53.4 to 63.5. The proportions of 4-locked and 5-locked bolls were so nearly equal in these samples that this factor can not explain the results.

LARGER PROPORTIONS OF FIVE-LOCKED BOLLS.

Experiments in the acclimatization of types of cotton new to the United States have shown that the number of locks in the bolls is often greatly reduced in the first planting and gradually returns to normal proportions as acclimatization proceeds. The most striking example of this fact was brought to my attention at Falfurrias, Tex., by Mr. Rowland M. Meade. Countings of the bolls of 42 of the Kekchi plants showed a total of 42 three-locked bolls, 202 four-locked bolls, and 6 five-locked bolls. On the other hand, 7 plants of an acclimatized stock of Kekchi cotton grown close by yielded 5 three-locked, 81 four-locked, and 91 five-locked bolls. In the acclimatized stock about half of the bolls, 51 per cent, had five locks, a proportion similar to that of our United States Upland varieties, while in the planting of imported seed the 5-locked bolls had been reduced to less than 3 per cent.

Similar tendencies toward a reduction of the numbers of locks in varieties grown in new places have been shown in our United States Upland varieties, though to a very much slighter extent, as might be expected. Countings of locks of Parker cotton made by Mr. C. B. Doyle at Del Rio, Tex., in 1908, gave an average of 31 five-locked bolls per plant in a first-year row and 47 per plant on the second-year row, while the 4-locked bolls had advanced only from 32 to 41.

AGE OF SEED AND DIFFERENCE OF CROPS.

The method of testing the second and third generations of a variety of cotton in a new place has been to compare these generations with plantings of the same original stock of seed held over for this purpose. While it is difficult to see how a direct test could be made in any other way the plan might be open to objection if it could be shown that plants raised from old seeds were more diverse than those that come from seeds raised in the previous year. Though no formal test of the relation of age of seed to diversity has been made, it may be said that neither from our experiments with cotton nor from what is known regarding other plants is there any indication that old seeds are likely to yield more diverse progeny than are new seeds.

The evidence, such as it is, seems to be more favorable to the opposite idea that less diversity appears in plants raised from old seed. Our nearest approach to a definite test was at Kerrville, Tex., in 1907, where a row test with old Lockhart seed of Triumph cotton stood adjacent to a field planted with new seed from Lockhart. The plants raised from the old seed appeared distinctly better and more uniform than those from the new, though the experiments were not of such a character as to completely exclude the possibility of influence from differences of soils or dates of planting.

It has also happened in several of our experiments with the Central American types of cotton that seed 2 or 3 years old gave more fertile plants than had been secured from the first plantings of the same stocks in the same places. Though the possibility that more favorable seasons may be responsible for these differences is not to be excluded, the better results from the old seeds are at least worthy of note. If the undesirable diversity can be avoided or diminished by merely holding over old seed, an advantage might be gained in the acclimatization or local adjustment of varieties.

It seems rather remarkable that this question of differences between old and new seed has not been more carefully tested. The idea that old seeds are better, at least in the sense of being likely to yield more uniformly productive plants, is firmly established in the popular mind, especially among growers and dealers in the seeds of melons and cruciferous plants. The difficulty is to distinguish between the possible influence of the factor of age and that of the factor of difference between crops of seed of the same variety.

It is stated by Mr. W. W. Tracy, sr., that seed dealers often come to recognize particular crops of seed as setting standards of excellence which later generations of the same stocks are not able to attain. A particular crop of seed of a variety of Savoy cabbage which came under the personal observation of Mr. Tracy gave progeny of greater and more uniform excellence than any other stock of seed that could be secured, not excepting the seeds grown from progeny of this same original lot, even when grown in the same field. The second generation, or grandchildren, was never equal to the first generation that came from the special stock of seed.[a]

Whether the retention of the later lots of seeds to an equal age would have given them the same excellence was not determined. Indeed, such a test would be very difficult in view of the fact that differences of age could never be equalized. Even though the popular idea of the superiority of old seed should be found to rest on the superiority of particular crops the continued excellence of these superior crops would still show that the increased age of the seed should not be supposed to make the progeny more diverse. It is to be expected that different crops of Triumph cotton raised at Lockhart might show differences of behavior at Kerrville, or even at Lockhart, but there is no reason to believe that this factor is of serious importance in comparison with local adjustment. The amount of diversity that appears at Kerrville is out of all proportion to the diversity that appears at Lockhart.

A similar idea, that uniformity increases with the age of the stock, is said to exist among breeders of new varieties of potatoes, who believe that bud variations are much more likely to occur in new varieties recently developed from seedlings than in old, long-established varieties.[b]

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[a] "Seed of the same stock and equally well grown, by the same cultivator, in the same location, differ in the variant tendency and the degree to which their product will be of the desired type in different seasons. The crop of seed of Green Globe Savoy cabbage produced by a certain grower in 1893 gave much more evenly typical plants and heads than any subsequent crop produced by him of the same strain, though he took the greatest care in selecting stock and growing the plants, even setting them in the same field that gave the superior crop. I have known a practical seedsman, one not likely to waste money on a mere theory, to pay treble the market price for a certain strain of peas produced by him four years before, though he had an abundance of seed of the same strain grown by himself in succeeding years—none of these later crops giving such good results as seed of that particular season." See Tracy, W. W., sr., Variant Tendency and Individual Prepotency in Garden Vegetables, in Memoirs of the New York Horticultural Society, vol. 1, p. 77, 1902.

[b] East, E. M. A Study of the Factors Influencing the Improvement of the Potato. Bulletin 127, Illinois Agricultural Experiment Station. 1908.

Still further back, we find a similar idea in the theories and methods applied by the Belgian horticulturist Van Mons to the breeding of pears and other fruits a century ago. Van Mons made a practice of sowing the seeds of the first fruits of his seedlings, which were supposed to deviate more readily from the parental type than seedlings obtained from mature trees. Though horticulturists admit that Van Mons was able in this way to produce a large number of superior varieties, some of which are still popular, the value of the system has remained in doubt. Some have believed that it did produce a rapid amelioration as claimed, while others have ascribed the results to accidental hybridization as likely to be of frequent occurrence in his gardens, where large numbers of different types of fruits were crowded together with no protection against cross-fertilization by insects.

To explain the supposed worthlessness of the seedlings of old and superior sorts, Van Mons advanced the idea that the improvement had distinct limits and then suffered a sudden and complete decline. This idea appears to have been based largely on the inferiority of seedlings of some famous old southern varieties which had been carried into more northern regions. It is quite conceivable from the standpoint of the behavior of cotton that the change of conditions might render the seedlings of southern varieties inferior to those that Van Mons was able to derive from native Belgian stocks. A statement made by Downing in his discussion of Van Mons, that there was a marked and unexpected decline in the quality of seedlings raised by colonists in New England, also suggests the possibility that factors of acclimatization and local adjustment may have to be considered in the breeding of fruits as well as in annual crops.[a]

METHODS OF TESTING COTTON VARIETIES.

Failure to take into account the factor of local adjustment may vitiate any test of varieties. A new variety not really superior, but carefully selected and locally adjusted, may appear to be better than a really superior old variety, if the seed of the latter is brought in from a distance and the comparison is made without the precaution of local adjustment. Conversely, a really superior variety brought into a new place may suffer by comparison with inferior stocks which have the advantage of better local adjustment.

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[a] "The first colonists here, who brought with them many seeds gathered from the best old varieties of fruits, were surprised to find their seedlings producing only very inferior fruits. These seedlings had returned by their inherent tendency almost to a wild state. By rearing from them, however, seedlings of many repeated generations, we have arrived at a great number of the finest apples, pears, peaches, and plums." See Downing, A. J., The Fruits and Fruit Trees of America, 1845, p. 7.

It is not safe to assume that any single planting can determine whether a new variety is suited to any particular set of local conditions. The only evidence that first plantings can give us is to show the extent to which new conditions can disturb the usual expression of characters of varieties.

The failure of tests of cotton varieties to yield practical results does not arise from any difficulty in finding differences between the behavior of different varieties of cotton when planted side by side. The trouble usually is that differences are too great and too frequent. A variety which in one year appears to be among the best may appear in the next year among the worst. The experimenter gains the impression that varieties of cotton have an extreme sensibility, not only to local differences, but to seasonal changes. This appearance of very great delicacy of adjustment makes testing appear almost in vain, especially in regions where the seasons are capricious, as in Texas. The experimenter gains no confidence in the uniformity of his results and is unable to give the farmer the practical advice that he desires.

The need of making allowances for local adjustment shows that any practical test must require at least two or three years before we can hope to ascertain whether a new variety is really well adapted to local conditions or not. Nor is it reasonable to suppose that the mere repetition of the usual tests for two or three years will furnish the desired information regarding the value of varieties. To make the test effective the experimenter must be acquainted with the normal form and methods of growth of the varieties so that he can select the plants that best conform to the varietal standards. It is only by the selection of the plants that fail to be disturbed by the new conditions that the possibilities of the variety can be ascertained.

The recurrence of diversity in a variety as a result of new conditions has some of the same effects as hybridization. The stock is no longer "pure," in the sense that it no longer yields uniform progeny. As the plants that have undergone definite changes of characters now differ in the same way as distinct varieties, a stock containing such mutations can no longer be said to represent a single variety; it has become a mixture of varieties and of crosses between them. Just as we would not think of beginning a variety test by mixing our seeds, so we ought not to consider that we can make a fair test of any variety after it has split up into other varieties.

The behavior of a variety in new places may very properly be tested from the standpoint of new-place variation to learn the nature, number, and extent of the changes that occur, and the practicability of avoiding them by acclimatization and local adjustment. Not until local adjustment has been accomplished, so that a variety behaves with a normal degree of uniformity, does it become possible to make an adequate final test of the variety—a test which determines whether the variety is really adapted to the conditions and is really better or worse than other varieties also adjusted to the conditions.

It may be that some relation can be discovered so that we can judge from the first behavior of a variety what its later behavior will be. It appears reasonable, on the surface, to suppose that a variety which shows many changes in a new place will continue to be less stable than another variety that behaves much more normally in the first year. But a little further thought robs us of even this logical assurance, for it is easy to understand that the behavior of a variety in a new place may have more relation to the place from which the variety has come than to its inherent possibilties of becoming adjusted to the new place. A variety brought from similar conditions, so as not to be upset by the transfer, might appear at first distinctly superior to another variety which had not had any previous opportunity to gain adjustment to such conditions.

To judge from indications of the first season it would have appeared quite hopeless to expect any normal behavior from some of our imported varieties which showed complete changes of habits of growth and became almost completely sterile. And yet these same varieties have later returned to normal characteristics and fertility. In view of such facts it would seem that the minor aberrations of our domestic varieties can hardly be taken seriously as indications of special, exclusive adaptation to the conditions in which they happen to have been bred. These wider possibilities of adaptation give new importance to the testing of varieties, though at the same time they appear to greatly increase the difficulty of the work.

Not only must the tests be maintained for longer periods, but this very fact multiplies another element of difficulty, namely, that of protecting the varieties against admixture by cross-pollination while the tests are being made. This danger differs in different regions with the numbers of insects that visit the flowers, but in many localities it is quite unreasonable to suppose that a variety will remain pure after it has been grown for two or three years in close proximity to other kinds of cotton.

Thus it seems necessary to admit that very little practical importance can be attached to either of the two systems of testing cotton varieties that have been depended upon in the past. The farmer's planting of a small amount of seed of a new variety can not be relied upon to give him any true idea of the value of the variety, or even to place him in adequate possession of the variety. Neither does the assembling of a large number of varieties by the experimenter for tests of yields enable him to decide which is the best stock, even for the region in which the experiment is made.

A first application of the facts of local adjustment in the testing of cotton varieties has been made in connection with the Central American and Mexican types recently introduced because of their weevil-resisting adaptations. Astonishing claims of superiority for the new varieties could have been made if we had waited until acclimatization had been completed and then tested them in comparison with United States Upland varieties which had not been locally adjusted to the places where the imported varieties had been acclimatized. The differences are much less striking when the imported varieties are compared with the best of our Upland stocks which have received the same selective attention that the new types have had, and in the same places. Nevertheless, if the new sorts continue to hold their own or to excel under such circumstances their general use can be advised with much better justification.

If the imported varieties had been distributed for general planting without these more thorough tests and without taking the facts of local adjustment into account, the result would doubtless have been the same as in many other instances where new varieties of plants in the hands of the practical farmer or gardener fail to show the distinct superiority claimed by those who have originated or imported them. Such discrepancies are commonly explained as due to misrepresentation by the dealer or to the overenthusiasm of the breeder, but the phenomena of local adjustment show that differences of this kind may also have a basis of actual fact.

METHODS OF INTRODUCING NEW VARIETIES.

The bearing of local adjustment on the introduction of new varieties is quite as serious as upon methods of testing varieties. No matter how superior a variety may appear in one locality, where it may have been carefully bred and adequately tested, it is not safe to assume that it will show its superiority in other regions until it has passed through the process of local adjustment. Nor is it any longer possible to believe that the farmer can ascertain the true value of a new variety by the traditional method of making a small trial planting and saving the seed of this to use in later years for general crop purposes.

The facts of local adjustment show us that the first planting of even a carefully selected high-grade variety in a new place is likely to result in an immediate deterioration of from 10 to 20 per cent in the yield, and as much, or more, in the quality. Unless this deterioration is avoided by removing the changed individuals from the stock, subsequent generations may be expected to show a gradually increasing deviation from the standards of the variety.

Unless the farmer takes special precautions to isolate his new variety, which he is not likely to undertake for a small sample of seed, and may be unable to accomplish at all when his neighbors are growing other kinds of cotton, the new stock will be badly infected with hybrids by the time he has multiplied it and secured enough seed for regular field plantings. And if, on the other hand, the farmer does isolate his new cotton he will not be able to make a direct comparison with the variety he has previously grown.

And even if the farmer succeeds in avoiding mixture of pollen by insects, there is still to be encountered the almost equally serious difficulty of avoiding mixture of seed at the gin. It is difficult to imagine a system that would more effectively conspire against the maintenance of pure-bred varieties of cotton than our American cotton gin, where the seed from each farmer is likely to receive an admixture from any other farm or from many farms together. Unless the farmer takes the unusual pains to see that the gin machinery is thoroughly cleaned out before his special stock is ginned, he has no reason to expect that his new variety will escape admixture, no matter what his previous precautions may have been. And to have even the opportunity to have the gin cleaned, he will usually be compelled to store his cotton till the end of the season.

These difficulties will in general conspire to prevent any real test of a new type of cotton, for by the time this test can be made the variety will have become seriously deteriorated, both by variation and hybridization. In addition to this, it is to be recognized that even if an individual farmer were to take the necessary precautions of carefully selecting and isolating his new stock, the prospects of his being able to secure any direct advantage from his efforts would still be very unfavorable. Unless he is a very large producer, and is thus able to market his crop separately, he is not likely to secure any advance in price. Ordinary buyers would not give him a better price than they were giving his neighbor who had made no improvement in the quality of the product.

Thus it appears that an entirely different system of introducing new varieties of cotton is needed if their full value is to be secured for the farmer. The work must be planned from the standpoint of whole communities, instead of from that of individual farmers. The seed must first be locally adjusted to the new place and must be grown exclusively in the region if it is to be protected from mixing with other varieties. If the full value of improved strains is to be gained, whole communities must unite in their production, so as to supply special markets or to secure special attention in the trade.

The present multiplicity of cotton varieties is recognized as a very unfortunate condition from the commercial standpoint, as well as from the agricultural. A very large proportion of the varieties are known only in restricted regions, to which they are supposed to be specially adapted. Reasons for this opinion have been found in the fact that these local favorites often fail to distinguish themselves when carried to other districts and yet are able to hold their own at home, even in comparison with high-grade varieties from other places.

While it is certainly to be expected that cotton varieties, like other kinds of plants, are really different in their adaptive characters, so that some are better suited than others to a particular set of conditions, the facts of local adjustment show us that it would be very easy to overestimate these special adaptations. Not until a new variety has reached the condition of local adjustment can the question of special adaptation to the local conditions be fairly tested, as has been seen in the preceding chapter. And until the importance of the factor of adaptation has been determined in this way we can not be sure that there is any practical necessity for the present multiplicity of varieties.

The number of varieties is increasing annually through the efforts of seedsmen to satisfy the popular demands for novelties. Superior new varieties should be welcomed, of course, but there is seldom any general agreement that the new varieties are better than the old. Though often widely disseminated by advertising, they are seldom able to supplant the old in any complete manner. No progress is made toward the desirable policy of uniformity for the whole community.

From present indications it appears quite possible that the factor of local adjustment may often prove to be larger than the factor of special adaptation. If this should be the case, much may be gained by extending a few of the best varieties over larger areas and discouraging the cultivation of all of the local varieties that can be replaced with others that are as good or better. Varieties that have an essential superiority will tend, of course, to maintain themselves and to spread into adjoining districts from the center where their superiority is definitely recognized. The problem is to facilitate such extension of good varieties by more definite determinations of their value in the outlying regions. A local variety called "Beat All," which has been grown and carefully bred in southern Georgia for nearly fifty years, is reported by Mr. F. J. Tyler as more popular in its home district than any other. Mr. Tyler considers this variety the best in the district, especially for poor lands, and states that it is fast replacing all other varieties. But when the same variety was tested (under the name "Hart's Improved") at the Georgia station, only 100 miles away, it stood at the bottom of the list. So great a contrast would not be likely to appear if tests were made between locally adjusted stocks.

Local adjustment may be looked upon as a plan for the establishment of many local strains of each of the more desirable varieties of cotton, but these strains are to be kept as much alike as possible in their commercial characters instead of each locality carrying on an independent selection based on an independent standard of its own.

Instead of taking it for granted that each locality must grow a different type of cotton, we ought to begin with the opposite idea of extending a few of the most desirable types as widely as possible through the cotton belt. Real limitations will doubtless be found after the varieties have been studied from the standpoint of local adjustment, but we should not assume that the limits have been reached until they are really encountered and we can learn what they are. Many experimenters with varieties of cotton and other crops have been content with the simple idea that the varieties are different, and have not felt any further obligation to ascertain the nature of the differences. Nevertheless, the need of more adequate knowledge in this field has also been clearly appreciated by some of our students of agricultural science. A very definite statement of this kind was made over twenty years ago by the late Dr. E. L. Sturtevant:

> The true study of a variety, to be of value, must embrace the properties of the plant, whereby certain adaptations are attained which render the variety better fitted for certain conditions of culture. Thus we would know of grain whether stiffness of straw or weakness of straw, whether ability to endure high cultivation or thin seeding or hardiness, etc., are an inherent property of the variety. We would know whether some varieties are more resistant to drought than others or can withstand wetness. We would know the relations of the plant toward conditions apt to occur in cultivation, and the better we know these, the more reliable become the conclusions which are derived and disseminated as an aid to the cultivator. * * * For us to say at the present stage of agricultural study that one variety is best, and inferentially that such a variety should be adopted by all, would savor of quackery. The best reports we can offer are the results of trial under conditions as noted and memoranda of variety peculiarities or such of them that we are able to definitely record.[a]

In this experimental study of cotton varieties from the standpoint of this distinction between local adjustment and adaptation to special conditions, so as to determine the true values of the different varieties in different parts of the cotton belt, the farmer is in particular need of the assistance of the Department of Agriculture and the State experiment stations. It is not to be expected that the efforts of individual farmers will be able to make adequate tests of this kind, for the number of varieties is too great and too much time and labor are required.

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[a] Sturtevant, E. L. New York Agricultural Experiment Station, Fifth Annual Report for 1886, p. 71.

RELATION OF LOCAL ADJUSTMENT TO OTHER VARIATIONS.

ENVIRONMENTAL CHARACTERS ALSO HEREDITARY.

It is usual to think of the characteristics of plants and animals as contributed by two general factors, heredity and environment, some characteristics being assigned to one factor and some to the other. Much effort has even been spent in attempting to determine whether characters supposed to come from the environment could become hereditary. Some writers have considered that the environment was partly or wholly responsible for the evolutionary development of plants and animals, while others have denied even the possibility that characters acquired from the environment could become hereditary.

In the light of our present knowledge the distinction between hereditary and environmental characters appears less serious. The only difference seems to be that the so-called environmental characters are more readily changed and adjusted to external conditions, not that they are less hereditary than other characters. The readiness with which many characters can be accommodated to changes of environment have led many writers on evolution to suppose that such characters are not hereditary. It might with equal propriety be alleged that they are more truly and effectively hereditary than other characters, since their powers of accurate accommodation to a particular condition do not appear to be impaired by long periods of disuse or by varied experiences of other kinds which notably disturb the adjustments of characters that have less direct relations to the environment.

It is not necessary to suppose that any of the characters of plants or animals are directly due to the environment, or that any characters are entirely independent of environment. Changes of characters following changes of environment can be thought of as representing responses or accommodations to external conditions, or influences of the conditions upon the processes of heredity. These relations are sensitive in many different degrees with different organisms and with different characters. Some characters are greatly affected by changes of external conditions and others very little.

Changes of accommodation, like the round leaves which give place to narrow-lobed leaves when amphibious buttercups are grown in water or the changes from fruiting branches to vegetative branches in cotton, can be considered as regular reactions or responses to changes of external conditions. To recognize a change of characters as a response is not the same, however, as to suppose that the character itself is in the nature of a response to a condition. The narrow leaves are not thought of as being caused by additional water in the plant, but as being put forth by the plant as a consequence of the change of conditions. The internal machinery of the plant that enables it to put forth the two kinds of leaves is something quite different from the air or the water in which the leaves may grow. The change of expression of the characters is an internal process, of which we know nothing except the visible result, that the plant takes on a different method of growth. While we do not understand the internal mechanisms that enable one environmental character to be substituted for another, there is no reason to consider this fact any more mysterious or any more significant from the standpoint of heredity than the further fact that characters may also change and alternate in expression without any regularly corresponding changes in the environment. In some kinds of plants, such as the juniper and the eucalyptus, the same individual may bear at the same time two very different kinds of leaves, showing that such differences lie, first of all, in the plants themselves, rather than in their environments.

CORRELATION OF CHARACTERS AND NEW-PLACE EFFECTS.

The phenomenon of correlation may also assist us in understanding the fact that new conditions call forth diversity. Correlation itself is only inadequately understood, but many examples have been collected by students of heredity. By correlation we mean that two or more characters tend to be brought into expression together. Correlation is said to be complete if one of the characters never appears without the other. Or there may be lesser degrees of correlation where the characters are more often found together than apart. As an example of a kind of correlation that is very general in cotton there may be mentioned the tendency of longer lint to accompany a narrower, sharp-pointed boll. This correlation not only applies to different species and varieties of cotton, but appears to hold even between individuals of the same variety. It is always to be expected that a plant with more pointed bolls than its neighbor will have longer lint. There is no obvious reason why this should be true, for the lint does not lie extended in the bolls, but is packed around the individual seeds. There is no apparent reason why a rounded boll should not contain long-linted seed as well as a pointed boll.

New-place effects observed in imported types of cotton appear to be regularly accompanied by correlated characters. Thus if the plants grow abnormally large and robust, the fertility is not only greatly reduced, but the number of locks in the bolls may be distinctly lessened as well as the amount, length, and quality of the lint. Such facts show that the changes called forth by the new conditions are not confined to characters that are usually supposed to be directly related to the environment. When great individual diversity appears, however, we are carried beyond the idea of correlation as-usually understood, and have to fall back upon the idea already suggested that the changing of the accommodation characters may carry with it a disturbance of the internal relations which control the expression of the other characters.

The phenomena of correlation are worthy of careful consideration in our attempts to understand the workings of the internal machinery of heredity. The general correlation or tendency for smaller and more rounded bolls to produce short lint may render the lint liable to deterioration through any external agency that affects the shape of the bolls. At Yuma, Ariz., in 1908, a considerable series of Upland types of cotton included in our experimental plantings showed a very general tendency to small rounded bolls, and there was an equally general shortening of the lint.

It also appears to be a rule with the Upland cotton that luxuriant growth tends not only to reduce fertility and make the crop late, but also to render the lint inferior. Thus at Del Rio, Tex., in 1908, several selections of the Parker and other types of Upland cotton, which grew more luxuriantly than in 1907, showed distinctly inferior lint. In some cases the progeny of plants that yielded notably good lint in 1907 gave not a single plant with good lint. The advantage which appeared to have been gained in the year before from local adjustment was much less apparent in 1908, as far as the lint was concerned. It was noticed in several cases that the plants with the best lint were at the ends of the rows where there was more exposure to light and less competition of roots. Thus it appears that luxuriant growth does not necessarily conflict with the production of good lint, but that overgrowth, along with overcrowding and overshading, is regularly accompanied by deterioration of the staple. That unfavorable conditions might reduce the number of bolls on the plant would not be surprising, but there is no obvious external reason why the lint inside the bolls should be so definitely affected by the external conditions, unless it be through correlation with the form of growth adopted by the plants. If we can determine the extent to which the lint of different bolls of the same plant may be affected directly by differences of temperature and sunlight a better idea of the importance of this correlation may be gained.

ENVIRONMENTAL CHANGES ACCOMPANIED BY INCREASED DIVERSITY.

When we study with greater care the changes that occur under the new conditions, we find that they are not confined to characters that are directly connected with the external conditions, those that are shared by all the plants in the new environment. We find that these more general changes of accommodation to external conditions are often accompanied by even more definite changes in the individual plants that greatly increase the amount of differences among them. To transfer a variety from a moist to a dry region may result in the plants being more hairy, but it is also likely to result in some plants becoming more varied in other characters of their leaves than they were in the previous locality. The increase of diversity is just as concrete a fact as the change of accommodation, and often more important for agriculture, since it is this diversity that lessens the crop rather than the general change of characters in the direction of accommodation to the new conditions.

The undesirable increase of diversity may be considered as an indirect result of the change of conditions incidental to the more regular accommodative changes of characters which changes of environment call forth. It does not seem unreasonable to suppose that the making of one readjustment among the characters should disturb another adjustment in mechanisms as delicate and highly complex as organisms. But whatever the explanation, the facts remain that diversity is increased by new conditions and that this diversity causes deterioration and decrease of the crop, and that these injuries can be avoided in later years by renewed selection to establish and maintain the local adjustment of the variety.

Changes of accommodation that are shared by all the individuals can be related to different factors of the environment, heat, light, moisture, or substances in the soil. To investigate these relations is more the object of the science of ecology. The diversity shown by the different individuals constitutes another group of phenomena, less directly related to ecology than to the science of heredity itself. The same internal instability is likely to be aroused by a very different external change. It has been observed that the mutations that arise in one place are no more alike among themselves than those that arise in a very different place. In seeking to understand such diversities we study first the behavior of the plants themselves, rather than their environmental relations. We no longer hope to explain the origin of particular characters by particular conditions, but accept the organisms and their varied characters as already existing. We must seek to know the facts of behavior before attempting to change them.

EFFECT OF SEASONS AND TIMES OF PLANTING.

An unfavorable season may have the same effects upon variation as a transfer into a new region, as already noted. The seasonal differences in the same place may even exceed those of different places quite widely separated. An excellent example of this has been noted by Mr. F. L. Lewton. A white-seeded Mexican cotton grown at Victoria, Tex., in 1906, and at Falfurrias, Tex., in 1907, retained the white-seeded character without variation, but in the season of 1908 the same stock planted again at Falfurrias showed a considerable number of distinctly greenish seeds, and still larger numbers of seeds slightly tinged with green or brown, and only a small proportion of seeds of the original white color. This change occurred not only in plants grown from seed raised at Falfurrias in 1907, but also in those raised from some of the seed of 1906, the same stock of seed that had produced only white-seeded plants in 1907. Thus there seems to be no room for doubt that the conditions at Falfurrias in 1908 were able to effect a change which had not been called forth by transfer from the Mexican State of Durango to Texas.[a]

A similarly general change in the habits of branching of the Parker variety of Upland cotton occurred at Del Rio, Tex., in 1907. No less than six plantings of different stocks of seed of this variety showed a distinct tendency to depart from the normal long-branched habit of this variety and go over to the semicluster habit, as a result of a shortening of the joints of the fruiting branches, as already described in a previous report.[b]

Though there could be no doubt that the conditions were responsible for strengthening this tendency to shorter branches there is also no reason to suppose that the shorter joints represent a character that came in from the environment. It is a matter of observation that the tendency to vary in the direction of shorter joints is very general, not only among varieties of cotton but in many other plants. The tendency is more frequently manifested as a definite change or mutation of an individual plant growing, it may be, with hundreds or thousands of others that do not change. The behavior of the Parker cotton at Del Rio is of interest as showing that external conditions may at times interfere to accelerate or intensify a tendency to change that under other conditions would remain entirely latent.

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[a] Two cases of differences in the seed characters of the same individual plants in different parts of the season have been noted by Mr. Lewton. In a picking of a selected plant of Mexican cotton at Del Rio, Tex., October 3, 1907, all the seeds were coated with olive-green fuzz. Another picking made October 22 showed about half of the seeds nearly smooth. In the bolls picked from a selected plant of the Pachon cotton from western Guatemala at Yuma, Ariz., November 11, 1907, there were 42 per cent of smooth seeds, while in an earlier picking from the same plant (September 9) almost all of the seeds were fuzzy, though in neither case were the seeds as heavily coated with fuzz as is usual with the Pachon cottons.

That changes in the color of the fuzz are likely to occur as a result of transfer from Guatemala to Texas was also shown by a plant of Kekchi cotton at Kerrville, Tex., which produced 42 per cent of grayish green seed. This plant was from a stock of seed specially selected by Mr. Lewton in Guatemala, where the Kekchi cotton has the seeds densely covered with white fuzz with great regularity. Large amounts of seed from numerous localities in the Cahabon district of eastern Guatemala have been examined by Mr. Lewton without finding any smooth seeds or colored fuzz. Many examples of colored fuzz have occurred in the second generation of the Kekchi cotton in the United States, but the possibility of hybridization was not excluded. Hybrids usually have green fuzz. See Reappearance of a Primitive Character in Cotton Hybrids, Circular 18, Bureau of Plant Industry, U. S. Department of Agriculture.

[b] Cook, O. F. Suppressed and Intensified Characters in Cotton Hybrids. Bulletin 147, Bureau of Plant Industry, U. S. Department of Agriculture. 1909.

Even the time of planting may have a definite effect upon the habits of growth and fertility of the plants, as can be easily seen when the same kind of cotton is planted in adjoining rows at different dates. Very early plantings, if they are not actually killed by frost, may be seriously injured by cold weather so that the plants make very slow growth. Many individuals may remain permanently stunted, or if they finally grow to full stature may do so only late in the season and produce no early bolls.

Plantings made somewhat later, that begin their growth while the weather is still cool, but without being stunted, have a distinct tendency to produce fruiting branches low down on the stalk, and are thus able to set an early crop of bolls. Late plantings, that begin their growth in warm weather, become too luxuriant at first and produce sterile vegetative branches at the base of the plant, instead of fruiting branches. The result is that the cotton that is planted too late in the season may require a longer time to set the same number of bolls than an earlier planting of the same cotton in the same place.

These facts explain the failure of experiments that have been made with very late plantings, in June, in order to "starve out" the boll weevils in the spring months. Even if no boll weevils were present these very late plantings could not be expected to yield as well as the earlier plantings. In the presence of boll weevils there may be a total failure of the crop.

The facts also explain why in southern Texas plantings made in April and May often yield larger crops than plantings made in March. Conspicuous examples of this were observed at Del Rio, Tex., in 1907, where fields planted in April and May were distinctly better than March-planted fields, in spite of the fact that weevils were present in abundance early in the spring in cotton that had survived the winter. In an experimental field planted May 22 the crop was uninjured even as late as October 2. Most of the plants remained entirely untouched by the weevils, showing no punctures on squares or bolls.

The ability of later cotton to overtake and outyield earlier plantings, even in the presence of the boll weevil, was definitely shown in a succession of plantings of Triumph cotton at San Antonio, Tex., in 1907. A planting made on March 8 was not only outyielded by adjacent plantings of March 23 and April 7, but the later plantings actually ripened larger proportions of their crop before the 1st of September. The yields for the three dates of planting stood in the proportion of 1,109 pounds per acre, 1,220 pounds, and 1,190 pounds, whereas the corresponding percentages of cotton ripened before September 1 were 65, 69, and 76. The more rapid development of the April and May plantings produced buds and bolls faster than the weevils were able to destroy them. The growth of March plantings may be so seriously retarded by the effects of cold weather that the production of weevils overtakes the cotton, especially if one or more of the early crops of buds are blasted and "shed," as often happens when the plants are checked by unfavorable weather.[a]

AGGREGATE AND PROMISCUOUS MUTATIONS.

The behavior of the Parker cotton at Del Rio shows that it is sometimes possible for external conditions to induce a change in the expression of a character that can also change without any apparent relation to external conditions, as when a single individual mutation occurs among many hundreds or thousands of plants that remain without change. The simultaneous mutation of all the individuals of a planting shows that the conditions of that planting have favored mutation. Though they do not prove that sporadic individual mutations that occur in other places are caused by external conditions, they do show that the two kinds of changes are not so essentially distinct as often supposed. Clocks that are able to strike by their own mechanism may also be induced to strike by external interference with the mechanism, though the striking itself may be the same in both cases. It is not necessary to suppose that there is any fundamental difference between mutations that take place spontaneously as the result of changes in the organic mechanism itself and those that appear to have more direct relations to external conditions. Whether many mutations occur, or a few, or a single one, the nature of the mutations may be much the same. Nor need we think that the relations to the external conditions are fundamentally different in cases where many plants mutate in the same direction from cases where they mutate in different directions.

Both aggregate and promiscuous mutations have been described in the same species, the garden tomato, the former by Dr. C. A.

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[a] Another experiment at the San Antonio Experiment Farm in 1908 gave similar results. Plantings of March 14, March 27, and April 25 yielded at the rate of 1,040, 1,099, and 1,142 pounds per acre, respectively. See Headley, F. B., and Hastings, S. H., The Work of the San Antonio Experiment Farm in 1908, Circular 34, Bureau of Plant Industry, p. 16.

White,[a] of Washington, D. C., the latter by Prof. E. P. Sandsten, of the Wisconsin Agricultural Experiment Station. In Doctor White's experiments whole plantings changed in the same direction, as in the case of our Parker cotton at Del Rio. In the Wisconsin experiments great individual diversity appeared, as in newly imported Central American cottons:

> The results of this excessive application of fertilizers soon became apparent. Hardly two plants in the bed of ninety-six were alike in all particulars. The stems in many plants were more or less decumbent, in others the internodes were elongated. A few plants were more or less dwarfed. The leaves showed marked variation in size, shape, and subdivisions; the whole bed giving an appearance of a variety test. The variation became more marked at the time of flowering. In many instances the blossoms were abnormal, both as to size and form. The stamens were greatly modified in several of the plants, and in one instance to such an extent as to become almost aborted. On the other hand, the pistils were greatly thickened and overgrown. One plant in particular, which showed marked modifications in the floral parts, was labeled and carefully watched. As the fruit grew it was noticed that the pistil and fleshy part of the ovary developed abnormally and there appeared to be no evidence of seed formation. During the process of growth and ripening of the fruit this fact was further emphasized, and when the first fruit was cut it was found to be seedless. The growth habit of the plant, while not excessive, showed a marked deviation from the ordinary type. The leaves were more divided and somewhat curly; they were also much smaller, and the general habit of the stem and branches was more or less decumbent.[b]

An aggregate mutation of many plants in one direction has greater resemblance to a change of adjustment or accommodation than has a promiscuous mutation, where each plant appears to change in a different direction, but the promiscuous mutation appears rather less remarkable than the aggregate if we consider that the external conditions have only disturbed the previous adjustments of the characters, without inclining them toward any particular new adjustment. As a matter of fact, the two forms of mutation are often closely associated in the phenomena of acclimatization. An aggregate mutation of all the plants to a different habit of growth is usually accompanied and followed by many and very promiscuous changes in other characters. A serious change in a character that is affected by the external conditions may be followed by changes in many other characters that have no apparent connection with external conditions.

The facts of mutation forbid any reliance in practical agriculture upon the idea that a stock which has been rendered uniform by selection will remain uniform if selection is relaxed. This idea certainly does not rest upon the observation of varieties as they are, but is an inference from the theory that evolution takes place by sudden changes of characters, like those that distinguish a mutation from the parent variety or from another mutation. An open-fertilized plant like cotton is more readily variable and hence more susceptible to new-place effects than a strictly self-fertilized plant like wheat or barley. Nevertheless, it appears that self-fertilized plants are far from being immune to variation. Even in vegetative varieties the different stocks derived from the same original individual may become very diverse as a result of bud variation, or may show different degrees of vigor and fertility.

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[a] The Mutations of Lycopersicum. Popular Science Monthly, vol. 67, p. 151.

[b] Sandsten, E. P. Excessive Feeding as a Factor in Producing Variations in Tomatoes. Twenty-second Annual Report of the University of Wisconsin Agricultural Experiment Station, pp. 301–304. 1905.

Acclimatization appears to be especially difficult with carefully selected, line-bred, self-fertilized varieties, such as those of wheat and barley. Specialists in these crops consider that the carefully selected stocks are much less likely to become acclimatized or adjusted to a new place than the types that have not been so carefully selected. A whole planting may show the same variation at the same time, an aggregate mutation instead of a promiscuous mutation, giving only one chance of adjustment to the new conditions instead of the vast number of chances afforded by promiscuous mutation. It is possible that something might be gained in such cases by making the experiment of acclimatization or local adjustment with cross-fertilized seed as affording a better opportunity for the display of a useful diversity.

RELATION OF SELECTION TO LOCAL ADJUSTMENT.

One of the reasons why the phenomena of local adjustment and acclimatization have been so largely overlooked and left out of account as factors of practical importance in agriculture is to be found in the general popularity of the idea that selection brings about the progressive improvement of plants and animals, as held by many writers on evolution. But for general scientific purposes as well as for practical reasons it is important to understand how the beneficial effects of selection are exerted. Ever since Darwin's first writings on the subject of natural selection were published the chief objection to his doctrines has been that they did not explain how selection could bring into existence the new or improved characters shown in the evolutionary progress of species. It has to be admitted that selection, whether natural or artificial, must deal with variations as accomplished facts. Selection gives one variation or characteristic a great advantage over other alternative characteristics, and thus allows it to become more quickly the character of a whole variety or species. Thus, natural selection might assist in diversifying two parts of a species that were living under different conditions, just as artificial selection may develop two or more different strains from one variety by saving in some groups the variations that are rejected in the others. But in all such cases selection still deals with differences as they appear, and does not help us to understand the nature of the differences themselves, or the factors that are responsible for their appearance.

Selection for local adjustment deals, like natural selection, with forms and characters that already exist in the plants; the question of improvement by further changes is not involved. The benefit that is secured when local adjustment is accomplished through selection is simply that of bringing the variety back to its previous standard of uniformity. Instead, therefore, of saying that local adjustment and acclimatization are to be explained by reference to selection, we ought rather to recognize that the facts of local adjustment and acclimatization throw light on the workings of selection. We must recognize the influence of external conditions to call forth diversity before we can understand the effect of selection to improve the variety again by restoring it to uniformity of expression. The Triumph cotton had already had the advantage of persistent selection, and shows the result in great uniformity. But when new or unfavorable conditions disturb this uniformity, a new "improvement" becomes possible through selection for a new adjustment to uniformity of expression of characters. It is this secondary selection that becomes particularly necessary to restore the uniformity of varieties in new places that we call local adjustment. The name, of course, is quite incidental to the recognition of the fact that changes of such great practical importance occur in our varieties and that they may be so easily corrected.

The fact that the selective improvement of domesticated varieties is a process of reducing or eliminating the individual diversity found among the members of wild species agrees completely with facts revealed in other lines of study. The individual diversity among the members of a wild species is generally very much greater than among the members of a domesticated variety. A progressive approximation to uniformity is attained through selection. The indication that the diversity is never entirely eliminated by selection, but is merely suppressed and is able to reassert itself after many generations, is also in full agreement with all the numerous facts of atavism and reversion. It is possible to understand that most of the changes which we ascribe to selection represent changes in the expression of characters already existing in the plants, and do not require the origination of any new characters not already developed in the more diverse ancestral groups from which our domesticated stocks have been derived.

It is sometimes supposed that uniformity represents the natural condition of reproduction and that all deviations must be due to hybridization. Nevertheless, the scientific world now generally recognizes the fact that sports or mutations do occur, that is, definite changes in the expression of character in members of otherwise uniform groups, without any admixture of blood. What has not been recognized hitherto is the fact that such changes are not necessarily confined to rare individual variations, but may take place simultaneously in large numbers, following changes of external conditions.

LIMITATIONS OF LOCAL ADJUSTMENT.

The process of local adjustment may be said to have been completed when a variety has become as uniform in a new locality as it was in the district where it originated or improved by selective breeding. It is not to be expected, however, that diversity will cease entirely. It does not appear that any amount of selection can prevent the transmission of the ancestral diversities or prevent the return of some of them to expression in occasional individuals. The most careful and persistent breeders have never succeeded in putting an end to the appearance of mutative variations. And even if we consider that the characters of the plants should remain uniform as long as the conditions remained the same, there would still be the difficulty that conditions are always differing, even when we try to make them as nearly alike as possible.

The effects of an unfavorable season may greatly overbalance the advantage that can be gained through selection for local adjustment in a favorable season, and may even increase the amount of diversity beyond that of the first year. It is accordingly to be expected that the second year of a new variety will sometimes be found inferior to the first year, in spite of an attempt at local adjustment.

Change of the crop from one soil to another may have its effect upon local adjustment, even in a favorable season, or may intensify the effects of an unfavorable season. The advantage that could be ascribed to local adjustment in our experiment at Del Rio, Tex., in 1907, was very slight in comparison with that shown at Kerrville, Tex., in the same season. In some of the varieties no advantage at all could be detected. Some of the selections brought from San Antonio or Victoria were better than those made at Del Rio in the preceding year. A change of the location of our Del Rio experiment from a gravelly slope, recently leveled for irrigation, to the deep silty soil of the river bottom gave a reasonable explanation of the discrepancy of results with respect to local adjustment. The Del Rio crop of 1907 was very much better than that of 1906, but the Del Rio selections from the crop of 1906 showed little or no superiority in 1907 to those brought from other places.

The conditions of the experiments of the two years at Del Rio were as essentially different as though they had been in distant localities.

The failure of the local adjustment effects to appear should be considered as confirming the reality of the phenomenon. On the other hand, it ought not to be thought that the excellent behavior of some of the Victoria and San Antonio selections under the very favorable conditions at Del Rio in 1907 would have been shown if they had been grown under the Del Rio conditions of 1906.

A bad season or an unfavorable location should not lead the farmer to suppose that his efforts for local adjustment must necessarily fail. Even though none of the plants in the field attain the full stature and fertility of the variety, the opportunity of selection is not necessarily destroyed. Plants that excel their neighbors under unfavorable conditions are likely to yield progeny that will show a corresponding excellence under better conditions.

Professional seed growers appreciate the fact that somewhat unfavorable conditions may render the work of selection more efficient than conditions that are ideal from the standpoint of crop production. Unfavorable conditions invite the appearance of unfavorable tendencies and thus facilitate the removal of the lines of descent in which these tendencies are strongest.

Very unfavorable conditions during the period of seed production may also prove to have an influence in local adjustment, since the adverse effects might not appear till the next generation. It is easy to understand that plants may develop normally while conditions are favorable, and yet fail to set equally normal seeds if the conditions became unfavorable. Many crop plants will complete their development in an apparently normal manner under conditions where they produce only inferior seed. The fact that the period of seed production is very long in cotton enables this plant to furnish even more definite evidence of the influences of external conditions, for the seeds and lint are often found to differ notably on the same plant.[a]

Instances may also be found where efforts at local adjustment will fail to bring a variety to a satisfactory degree of uniformity. It is not to be expected that a variety that fails to respond to local adjustment and return to a uniform behavior will equal a well-adjusted variety. If a variety fails to respond to local adjustment after a fair opportunity, it will be reasonable to consider the conditions are really not favorable; that the stock has been hybridized, or that it has never been brought to a condition of uniformity.

In view of the wide differences of soils and seasons that may be encountered on the same farm, ability to withstand changes of conditions without being injuriously affected is a factor of great importance in a field crop like cotton. There is no reason to suppose that the injurious changes of characters are entirely confined to strains of cotton that have been carried recently to new places. An unusual season may render conditions quite as exceptional as a new place and may have the same effect of arousing diversity.

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[a] A Study of Diversity in Egyptian Cotton. Bulletin 156, Bureau of Plant Industry, U. S. Department of Agriculture, 1909.

In considering the use of local adjustment as a means of removing or reducing these undesirable diversities there is no need to lose sight of the fact that varieties of cotton and other plants undoubtedly differ greatly in their relation to the local adjustment factor. Varieties that can not have their conditions changed without becoming injuriously diverse must be reckoned in the same general class as those that are narrowly adapted in other respects and refuse to thrive or to bear fruit outside of some particular district. Other things being equal, varieties less subject to disturbances of expression relations are always to be preferred. With cotton it would be very desirable if only one variety of cotton were grown over a large district, since the uniformity of the product is a factor of commercial importance.

DIFFERENCES BETWEEN LOCAL ADJUSTMENT AND BREEDING.

Though the work of local adjustment may be considered as a part of the art of breeding, in the largest sense of the word, the process of local adjustment is quite distinct and in some respects is even opposed to the processes that are usually given prominence in the improvement of varieties by breeding. The breeder seeks for new characters or new combinations, or to obtain still higher degrees of expression of desirable features, for something exceptional and different from the recognized varieties. By local adjustment, on the other hand, we do not seek to change the variety, but to prevent change by rejecting all the lines of descent in which changes appear.

When the commercial seed grower pulls out the " rogues " or " off " plants that do not " come true " to the characters of the variety he is not usually thought of as engaged in breeding, but only as preserving his stock from deterioration. The work of local adjustment is exactly analogous to the " roguing " of a variety. We are simply recognizing the fact that the transfer of seed to new conditions is likely to produce such large numbers of rogues that it is necessary to extend the roguing process from the hands of the seedsman to those of the farmer. The seedsman who does not practice roguing is reckoned as dishonest, because he does not sell " pure " seed, but allows seeds of rogue plants to be mixed in with the variety that he offers for sale. The farmer who neglects local adjustment need not be considered dishonest because he may not injure anybody but himself, but he is at least depriving himself of the advantage that he expects to secure from the seedsman.

Seedsmen not only pull out rogue plants that show definite differences in the characteristics of the leaves, flowers, or fruits, but they also take into account differences of behavior of the plants with respect to such qualities as vigor, fertility, and earliness. They know that the extent to which a variety may adhere to these desirable qualities depends largely upon the conditions under which it is grown. They recognize that even a slight departure from the normal qualities of the variety is likely to arouse more persistent differences in later generations, especially if the influence is repeated. A careful study of the behavior of varieties of garden peas with respect to the quality of earliness has been made by Mr. W. W. Tracy, sr., who states the following conclusions:

> Seedsmen commonly believe that, in the case of peas the character of the soil has a marked influence over the character of the plant, and that this influence extends to and is carried by the seed, but that such soil influence is decidedly cumulative in its effects, so that in practice they attach little importance to it for one season, but carefully avoid the use of stock seed which has been submitted to such influence for consecutive years.[a]

It is sometimes said that farmers ought to be as much interested in the breeding of their domestic plants as in the breeding of their domestic animals, because the practical importance is as great in the one case as in the other. This is undoubtedly true of the work of breeding as a whole. Local adjustment, however, is a subject which appears to have much more importance with plants than with animals, for plants are more susceptible than animals to changes of external conditions. Temperature is undoubtedly one of the chief factors that induce changes of characters in plants, whereas all of the higher animals and birds maintain their own temperatures with great constancy and have thus eliminated one of the chief agencies that disturb the hereditary processes of plants. Plants have to adjust themselves to wide extremes of external conditions of climate and soil, while many animals have large liberty of choice of environment.

The possibility of obtaining desirable variations by placing plants under conditions that call forth a wide range of diversity is worthy of careful consideration from the standpoint of the breeder, as an alternative of hybridization. The fact that a great majority of the variations are undesirable does not preclude the possibility that individuals of special excellence may sometimes be found, from which superior new varieties may be obtained, as from other mutations. The Triumph cotton itself is said by Mr. Mebane to have originated from a single peculiar plant of the Texas Stormproof variety, a plant that had all the present characteristics of the Triumph definitely developed. While there is nothing to show that the subsequent selection has changed or "improved" the variety, it has served the important purpose of maintaining its uniformity and productiveness.

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[a] Tracy, W. W., sr. The Influence of Climate and Soil on the Transmitting Power of Seeds. Science, n. s., vol. 19, p. 739. 1904.

Diversities that can be secured without hybridization may be found more valuable than the others, especially in seed-propagated plants, where the persistent diversities of hybrids seriously interfere with their utilization. This difficulty of "fixing the characters" is avoided in the case of the mutations, which are often constant from the first.

In local adjustment we have no interest in these possibilities of obtaining new varieties. Divergent plants, even though they may be as good or better than the regular stock of the variety, should not be retained unless they are to be separated for breeding purposes. To keep them in the field and allow their progeny to become crossed with each other and with the parental type is only to lose the new strains without making the old one any better. The same result is to be expected as when distinct varieties are crossed. The first generation may not be inferior, but later generations are likely to call forth a degenerative diversity similar to that which we seek to avoid by local adjustment.

In acclimatizing imported varieties it has appeared that the selection of types that depart from the usual form of the stock in its previous habitat is likely to delay acclimatization, for these are not as likely to "breed true" as plants that return more nearly to the accustomed form of the variety. There may prove to be a relation between the stability of new variations and the constancy or uniformity which has been attained in the stock in which variation appears. The constancy of the new forms is likely to be greater in local adjustment, for they appear to be more closely of the nature of mutations. Our experiments have not been carried far enough to determine the point, but it has appeared thus far that some of the variations that are aroused in new localities are likely to be as constant as the parent stock, or even more so.

The failure in the past to distinguish local adjustment from breeding is undoubtedly responsible for some of the apparently contradictory facts that have been reported. Local adjustment enables us to understand why large increases of yield can be secured at once by simple selection in the first year or two, and also why no similar rate of "improvement" is obtained in later years, after the variety has been brought to a condition of approximate uniformity.

The methods of breeding which are supposed to bring about true improvements of varieties by individual selection usually need to be practiced on a larger scale and with greater precautions against accidental errors than most farmers are willing to apply. Either the work is found too difficult and expensive or the numbers of plants that can be tested become so small as to seriously reduce the prospects of success. If we narrow our stock to progenies of a few individuals, these progenies have to be most carefully tested, for if a wrong selection be made permanent damage is done. The best stock may be lost by mere accident, and the accident may go unnoticed unless elaborate precautions are taken to equalize the conditions of the tests.

The more unstable or degenerate a variety is the more frequently will it show a marked response to selection. It is often assumed that the true value of a selected stock can be shown by comparing it with an unselected stock of the same variety, but the difference between the two ought rather to be looked upon as an index of the extent to which the unselected stock has degenerated. The true value of the selected stock can only be judged by comparison with equally selected and locally adjusted stocks of other varieties, to see which will show the best and most regular performance under the given conditions. Other things being equal, a stock ought to be considered better that does not "respond" to selection, for this indicates that all the individuals are nearly equal in their inherent qualities, whereas a stock that regularly shows a marked improvement from selection gives at the same time evidence of a more prompt and persistent recurrence of diversity, as a more frequent factor of deterioration and loss, unless more stable strains can be separated by selection.

The wide differences in yield which breeders have found among the progeny of individual members of carefully selected stocks are usually cited as proofs of the value of continued selection, but excessive variability of yield may also indicate that the stock is deficient in local adjustment or that it has reached a condition of serious degeneration. An interesting example of diversity in yields among a series of selections of cotton grown under the same conditions has been published by Mr. A. M. Ferguson in the Texas Stockman and Farmer for March 31, 1909. Out of 28 selections 12 gave total yields at rates of from 1,218 to 1,529 pounds per acre, while 13 selections fell below 1,000 pounds per acre, 8 below 900, 4 below 800, and 1 below 700, the figure in this case being 674 pounds. The yields from the first of the two pickings were even more unequal than the totals, ranging from 127 pounds per acre to 1,348 pounds.

If a large proportion of the progeny regularly prove to be deficient the only remedy may be to secure a better stock, one that is more uniformly fertile. A stock that gives us too small a proportion of high-grade plants may be less desirable than one that gives a larger proportion of plants of less conspicuous excellence. Many of our carefully selected stocks, both of animals and of plants, fail to maintain the standards of fertility that would be expected among normal individuals of an ordinary "mixed population." It is often assumed among breeders that strict uniformity in other varietal characteristics carries with it an equal uniformity of vigor and fertility, but this relation has not been established as a fact outside of varieties that are propagated by line breeding, and even these may deteriorate.[a]

Vigor and fertility represent physiological standards of organic efficiency. They are not to be looked upon as characters in the same sense as the minor details of color, shape, or function, but are rather to be considered as cooperative results of the activities of other characters and functions. It has yet to be shown that greater vigor or fertility can be attained in groups that are restricted to the expression of a single set of characters than in groups of greater individual diversity.

A further difference between local adjustment and breeding may be found in the fact that the diversities which make local adjustment a necessity are in some important respects different from those with which the breeder must deal in establishing an improved strain from a stock which has not been previously subjected to careful breeding. Though we may think of the diversity that arises in a new place as a return toward the diversity that existed before the variety had been rendered uniform by selection, the new diversity does not appear to be altogether the same as that of a group that has never been closely selected.

In an unselected wild stock the plants are individually different, but the differences are harder to detect because of the presence of many intermediate gradations. Ordinary "mixed populations" of animals or plants obey Galton's law of regression and tend to resemble their immediate parents instead of their remote ancestors. In a wild type the law of regression would aid natural selection in bringing the more favored characters into expression in larger and larger proportions of the freely interbreeding population. Mutations, on the other hand, do not appear to obey the law of regression, but may go back definitely to a character of a remote ancestor and show no influence from the immediate parents or grandparents.

In addition to bringing back the normal diversity of the wild type into expression mutative variations have two other very important elements of diversity. The first element is the diversity of more remote ancestors that would not tend to appear or to remain in expression under conditions of regression and free interbreeding. The second element is the suppression of many normal characteristics and coordinations, as in the cluster habit and the bullate leaves or the loss of fuzz or of lint. Darwin and many other writers have noted the general tendency of plants recently introduced into cultivation to "break" into diverse varieties.[a]

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[a] The Superiority of Line Breeding over Narrow Breeding. Bulletin 146, Bureau of Plant Industry, U. S. Department of Agriculture. 1909.

In strictly self-fertilized varieties like those of wheat and other cereals, selection can be said to have only one effect; it makes a stock more uniform in proportion as the diversities are rejected. Conditions of reproduction in the lines that are preserved are in no way affected by the taking away of the other lines. In plants that are subjected to frequent cross-fertilization, as in cotton, the selective restriction of descent to narrow limits or to a single line has an indirect effect upon the heredity of the plants that remain. It renders them much more uniform than before; that is, much more regular or "fixed" in the expression of their characters. While never attaining exact likeness, the great majority of them may differ only in the extremely slight details, usually termed "fluctuating variations" by writers on heredity. Plants that have attained this condition of uniformity, so that they show only fluctuating differences and produce progeny of equal uniformity, are said to be "pure" or homozygous, in the technical terminology of Mendelism. They tend more regularly to bring into expression only one set of characters instead of the indiscriminate diversity of wild species or of "unimproved" domesticated stocks.

Writers on Mendelism look upon self-fertilization as a means of separating the lines of descent that are uniform or homozygous from those that are diverse or heterozygous, as in the case of Mendelian hybrids. It ought also to be recognized that self-fertilization and other forms of restricted descent serve to establish the homozygous condition so that uniform progeny are produced instead of diverse progeny. The persistent application of a standard of selection tends to establish that standard for larger and larger proportions of the progeny unless degeneration ensues. Even the variations of homozygous stocks usually remain homozygous, though the act of variation is in itself a violation of the rule of homozygous uniformity.

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[a] "While specific stability under constant conditions appears to be the rule in nature, it is widely different in cultivation. When a plant is brought under cultural conditions it maintains its type for some time unaltered, then gives way and becomes practically plastic. From my experience at Kew, where I saw the process continually going on, I hazarded the generalization that any species, annually reproduced from seed, could be broken down in about five years.

"In nature we deal with a host of individuals; in cultivation with a very limited number. In my view specific stability is maintained partly by the weeding out of unfavorable variations, partly by wide interbreeding. Now, it is obvious that under cultivation the latter agency is inoperative, and cultural conditions bring other influences to bear, especially as regards nutrition.

"The races of Œnothera which De Vries has raised are nothing more than what a horticulturist would expect; and it may be conceded that if such races could hold their own in nature, distinct species might originate in this way. But there is no evidence that they do; and the probability of their being able to do so is against them.

"Cultural mutations seem, as a matter of fact, to have little, if any, capacity for holding their own in the struggle for existence. I can not call to mind a single instance of one which has been successful, and even in cultivation there is some reason to think that they are short lived; but this is a point on which we are in urgent need of carefully ascertained facts." See Thiselton-Dyer, W. T., Specific Stability and Mutation, Nature, November 28, 1907, pp. 78 and 79.

A line-bred variety tends to become "pure" or homozygous in all its characters, whereas broad-bred, cross-fertilized varieties may become homozygous in only a part of their characters, those that are specially selected. It appears to be possible to secure a considerable degree of uniformity in a desirable character without establishing uniformity in all other respects; that is, without placing the variety on a basis of complete line-breeding, which is a practical impossibility in open-fertilized plants grown as field crops, like corn and cotton. Varieties of corn attain a highly characteristic uniformity of ears without enforcing a requirement of uniformity in the plants. Egyptian cotton also has a high commercial reputation for uniformity, but has not been made uniform in vegetative characters to any such extent as some of our Upland and Sea Island varieties.

Selection for local adjustment of established varieties is much more practicable for the farmer than selection for breeding in unimproved strains. It is much easier to detect an aberrant individual in a group of plants otherwise closely similar to each other than to appreciate individual differences in a group where the diversity is general and indiscriminate. Variations that take place in varieties that have been bred previously into a uniform or homozygous condition are much more definite and hence more easily perceptible than the less definite differences found in unimproved varieties. Too much diversity will greatly increase the difficulty of selection for local adjustment, unless the farmer is thoroughly familiar beforehand with the normal type of his variety. Unless we are able to distinguish the type of the variety our efforts will only result in the saving of a collection of varieties, and the further mixing of these together can only mongrelize the stock still more.

LOCAL ADJUSTMENT AS A FARM OPERATION.

The facts of local adjustment will have a practical value to the farmer in proportion as they are able to convince him of the necessity of selecting his own seed. If by the light labor of selecting his seed from normal fertile plants he can increase the quantity and quality of his product from 10 to 20 per cent, he must recognize the fact that such selection is quite as practical a farm operation as planting, cultivating, or harvesting the crop.

The labor of such selection is very slight. It is not necessary to establish any absolute standards or score cards, and in almost every family there are men, women, and children well qualified by natural acuteness of observation to recognize the plants that are more fertile than their neighbors and to avoid those that deviate from the characters of the variety or have short, weak, or sparse lint. Normal characters and habits of growth, fertility, and good and abundant lint are the only features that need to be taken into account in maintaining the local adjustment of a variety. Selection for this purpose is a matter quite apart from the breeding of new varieties or of special strains by careful comparison of single individuals and the progeny derived from each.

Differences in vigor or fertility that can not be distinguished in the individual plants themselves will become apparent when the progenies of these individuals are compared. Selective breeding by means of progeny rows is a further step beyond local adjustment that will give the farmer a further improvement of his crop if he will take the additional pains that this system requires in raising the progenies separately, and keeping the stock pure. It is a mistake, however, to suppose that even the progeny row is a full substitute for local adjustment as a means of guarding a superior stock against deterioration. No matter how excellent a variety may be or how skillful the selection of the professional breeder who may have perfected it, the farmer will still need to maintain its efficiency by his own selection if he is to get the best possible results of productive efficiency.

SUPERIORITY OF HOME-GROWN SEED.

In thus urging upon the farmer the necessity of maintaining the local adjustment of whatever variety of cotton he may prefer to grow there is no intention of pronouncing any general conclusion on the much debated question of the superiority of home-grown seed over imported seed. One or the other of these alternatives is often argued as a general principle or policy of agriculture, whereas the question is really very complicated. Different principles have to be considered in relation to different crops. The growing of the seed of many highly specialized varieties of ornamental plants and garden vegetables, such as cauliflower and radishes, is confined to a single locality. By very careful treatment on the part of the grower the problem of local adjustment can often be avoided. A single crop can be secured from the imported seed, even under conditions where no good seed can be raised for a second generation, but with a field crop like cotton that can not be protected against variations of climate and soil the case is very different.

And even with cotton itself it is not to be expected that local adjustment will give equal advantages in all cases. Some localities may profit by the regular importation of seed from other districts. Experiments with newly imported cottons have shown in a few cases larger crops in the first year than have been obtained in later plantings of the same stocks. In such cases the transfer to new conditions, instead of throwing the plants out of adjustment and producing an injurious range of diversity, seems rather to give an unusual stimulation of growth, without inducing the sterility which usually accompanies such stimulation. Two instances were found at Del Rio., Tex., in 1908, where seed brought from Falfurrias, Tex., produced rows of plants that were distinctly larger than rows of the same varieties (Parker and Cook's Improved) grown from seed raised at Del Rio. But in both these instances the greater size was accompanied by a decrease of fertility, or at least of earliness. Thus no practical benefit was shown for such an exchange of seed.

With a forage plant or other crop grown for vegetative tissues alone a response of the same kind might afford a distinct advantage. If it can be found that the bringing of seed from one region to another uniformly results in such a desirable stimulation, and especially if it is accompanied by increased yields, such transfers of seeds between particular regions will need to be recognized as a regular feature of the agriculture of particular crops. This is a very different idea, however, from that of general advice for or against "change of seed."

Just as the diversity which arises in a new place may be compared to the diversity which comes by crossing, so it may be that a useful increase of vigor can be secured merely by placing plants under new conditions, like the vigor that comes from crossing. In both cases it is possible to think of the vigor as attending a change of characters, and this fact may be connected in turn with the further fact that varieties held rigidly and long to one uniform set of characters appear to suffer an eventual deterioration.

Though future experiments must determine the value of local adjustment in its application to particular varieties and conditions, our present facts are certainly sufficient to show that the usual methods leave out of account a physiological factor of great practical importance. Every farmer who plants the same variety for even a second year from seed of his own raising will find it to his distinct advantage to take the fact of local adjustment into account. He need not think of the advantage of selection of seed as connected only with a policy of slowly improving his stock by a persistent selection through a long course of years. He may secure a very distinct and practical advantage by selecting his seed for a single season, even if he intends to stop farming the year after, or to discard the variety he is now planting. While there is every reason to expect that a slow improvement may be wrought by persistent selective breeding, the neglect of local adjustment means that we forfeit the chance of making an immediate gain or of protecting ourselves against an immediate loss.

The selection of seed has seemed, even to the progressive cotton planter, as something out of his line of work, something to be done by the special grower or the seed dealer. Intelligent planters appreciate the importance of good seed, but they are usually content to show this appreciation by bringing in some well-recommended variety from a distance, growing it for a series of years until it appears to "run out," and then replacing it by another new stock. The fact that the new sort is often found to be better than the old is still accepted as proof of the value of this custom, notwithstanding all the evidence of experiments and demonstrations that better crops of cotton can be grown from seed raised in the same place than from seed newly brought in from a distance. The advice of the seed dealer to change the seed has appeared to the farmer to have quite as good reasons behind it as the advice of the experiment stations to make his own selection of seed.

Unless a fact is properly understood we can not separate it from its apparent contradictions. New seed may be better than home-grown seed if no selection has been practiced, but, on the other hand, the best new sort may fail to show its full possibilities when planted for the first time in a new place. Even the very best variety may need to be selected in the place where it is grown to get the best crop. The superiority of new seed and the superiority of home-grown seed are both facts, and they are not contradictory as they have long appeared to be. They help to explain each other when viewed in the proper light. The farmer can raise better seed of his present variety for himself than he can possibly buy from a dealer, but this does not mean that he is not to look for better varieties. It means rather that promising varieties must have fair chances to show what they can do by testing them for two or more years instead of judging their possibilities by the results of the first planting.

CONCLUSIONS.

The growing of a variety of cotton in a new locality is likely to bring about a distinct reduction in the yield as well as in the quality of the fiber. This deterioration has been found to be connected with an increase of diversity among the individual plants. Even when a carefully selected, uniform stock is used for the experiment a much greater amount of diversity may appear in a new place than when the same stock is grown under accustomed conditions of the previous locality where the variety was improved by selection.

The diversity that reappears in the first season when a variety of cotton is grown in a new place can be greatly reduced in later seasons by selecting seed from the plants whose characteristics have been least disturbed by the transfer to the new place—those that are the most fertile and have the best lint. This process of selection to restore the uniformity of a variety in a new place is called local adjustment.

Selection for local adjustment is distinct in objects and methods from breeding for improvement or for originating new varieties. The object of local adjustment is to preserve varieties already existing and guard them against recurrence of diversity. Practical advantages can be secured by simple selection for local adjustment without the separate testing of individual lines of descent, as required in breeding for improvement of a variety or when new breeds are to be developed.

The phenomena of local adjustment are of general scientific interest as illustrating one of the influences of external conditions upon the expression of characters in organisms. The recurrence of diversity in a previously uniform variety serves with other facts to show that ancestral diversities continue to be inherited, even when their expression is avoided by efficient selection. That changes of conditions can induce a return to diversity shows that the environment is able to influence the expression of characters and that its influence is not limited to characters that vary directly and regularly with changes of environment.

Apart from the effects of conditions which limit or inhibit the growth of the plants, two kinds of changes are found to follow transfer to new places: (1) Changes of accommodation to different conditions and (2) diversification or loss of uniformity. Changes of accommodation do not directly increase diversity, for they are shared by all the individuals, but changes of accommodation are often accompanied by changes of other characters which render the individual plants much more unlike than before.

It is not necessary to believe that the diverse characteristics that appear in the new place come into the plants from the external environment or that they represent direct effects of the environment upon the plants. It is more reasonable to suppose that new conditions induce diversity in an indirect manner by disturbing the processes of heredity, and thus allowing ancestral characters that had been transmitted in latent form to return to expression, or characters previously expressed to become latent. Recurrence of diversity may be quite independent of hybridization, although some of the results are very similar.

The phenomenon of local adjustment only strengthens the many other evidences that the uniformity of a variety of cultivated plants can be maintained only by persistent and vigilant selection. The decrease in the agricultural value of a variety that results from a return to diversity is as real and important as the agricultural improvement that is made when diversity is reduced by selection.

The facts of local adjustment go far to explain the apparently capricious behavior of cotton varieties in comparative tests, the same varieties often standing in entirely different relations to each other in different seasons. It becomes evident that the adaptation of a variety to a new place can not be fairly tested in a single season. Not until a new stock has passed through the process of local adjustment and returned to a normal degree of uniformity can the extent of its adaptation to the new place be definitely ascertained.

The facts of local adjustment indicate that our superior varieties may be found adapted to much wider regions than they now occupy. Varieties of real value should have their range extended through local adjustment, instead of being discarded because they fail to show their superiority in the first season. The wider extension of a few superior types of cotton would make it possible to abandon many local varieties and would constitute an important step in the progress of the cotton industry. Greater uniformity in the crop over large areas would increase its commercial value and simplify commercial problems of grading and marketing.

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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 160.
B. T. GALLOWAY, *Chief of Bureau.*

ITALIAN LEMONS AND THEIR BY-PRODUCTS.

I.—THE ITALIAN LEMON INDUSTRY.

BY

G. HAROLD POWELL,
Pomologist in Charge of Fruit Transportation
and Storage Investigations.

II.—THE BY-PRODUCTS OF THE LEMON IN ITALY.

BY

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Assistant Chief of the Division of Foods,
Bureau of Chemistry.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 17, 1909.

Sir: I have the honor to transmit herewith a manuscript entitled "Italian Lemons and Their By-Products," consisting of two papers, "The Italian Lemon Industry" and "The By-Products of the Lemon in Italy," and to recommend that it be published as Bulletin No. 160 of the Bureau series. These papers have been prepared by Mr. G. Harold Powell, Pomologist in Charge of Fruit Transportation and Storage Investigations, Bureau of Plant Industry, and by Mr. E. M. Chace, Assistant Chief of the Division of Foods, Bureau of Chemistry, with a view to publication.

The observations summarized in the first manuscript were made by Mr. Powell, who went to Italy in the fall of 1908 to study the methods used in the development of the lemon industry. During the trip through Sicily he was accompanied by Dr. Arthur S. Cheney, American consul at Messina, who was killed in the earthquake in December, who rendered the greatest service to the Department of Agriculture on this trip on account of his familiarity with the lemon industry and with the people. The paper on "The By-Products of the Lemon in Italy" was prepared by Mr. Chace, who investigated these products, especially the oil of lemon, in Sicily in 1908 for the Bureau of Chemistry. The Bureau of Chemistry also received much assistance from Doctor Cheney in connection with its work.

The lemon industry is increasing rapidly in the United States. The crop in California now amounts to from one-third to two-fifths of the total quantity used in the United States. The remainder of the supply is imported chiefly from Italy. The by-product business has not yet assumed commercial importance in California, but there is an increasing interest developing in this branch of the industry.

The observations made in this bulletin should be helpful to the American lemon industry in showing the status of the industry in Italy and the methods used in growing, marketing, and distributing the crop.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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ITALIAN LEMONS AND THEIR BY-PRODUCTS.

I.—THE ITALIAN LEMON INDUSTRY.

By G. Harold Powell, *Pomologist in Charge of Fruit Transportation and Storage Investigations.*

INTRODUCTION.

The lemon is grown in nearly all parts of Italy, from the provinces of Lombardy and Venetia on the north to the island of Sicily on the south. The distinction acquired by Italy as the lemon-growing center of the world is due principally to the fruit and by-products from the groves in the southern Mediterranean region, especially on the Sorrentine peninsula, across the bay from Naples, in the province of Calabria, and in Sicily. There are few parts of the world where horticulture has been more highly developed, where the products enter more widely into commerce, and where, on the whole, an industry has thrived more and has contributed to the welfare of a greater number of people.

In the provinces of the northern and the central part of the country the climatic conditions preclude the development of an extensive commercial lemon culture. Though a comparatively large industry was developed there in the past, lemon culture has been on the decline during the last decade in this part of Italy. The trees suffer too often from frost, from high winds, and from driving rains, predisposing them to disease and making lemon growing there a precarious undertaking. In southern Italy and in Sicily the climate is milder and more like that of southern California. The number of lemon trees in that part of Italy is at least fifteen times the number in California.

THE EXTENT AND LOCATION OF THE ITALIAN LEMON INDUSTRY.

It is difficult to obtain exact statistical information on the lemon industry of Italy. In 1904 there were about 17,000,000 citrus-fruit trees of all kinds in Italy, at least 8,000,000 of which are said to be lemons. Probably three-fourths or more of the lemon trees are located in Sicily. In 1898 there were over 6,000,000 lemon trees in

Sicily. The next most extensive regions are Reggio di Calabria and the Sorrentine peninsula, both on the mainland, the former having about a million trees and the latter 500,000 or more.

On the Sorrentine peninsula the most extensive groves, or gardens as they are called in Italy, are located on the Amalfi coast, at Majori, Minori, Amalfi, and to a smaller extent at other places from Cetra to Positana. The trees are planted on walled terraces on the mountain sides that rise abruptly from the Gulf of Salerno, as shown in Plate I, figures 1 and 2. The trees are covered with straw mats placed on trellises late in the fall, to protect them from frost during the winter months. There are many groves also on the side of the Bay of Naples in the vicinity of Sorrento, and other plantings in the vicinity of Naples, the trees in the Naples district in 1898 numbering 180,000. There are also many groves in the vicinity of Cosenza and Catanzaro and at Reggio, in the province of Calabria, the by-product industry having reached the highest development in the latter district. A map of Italy and adjacent countries is shown in figure 1.

Sicily is the heart of the lemon industry of the world. The groves are located near the coast along the northern and eastern sides of the triangular island, usually in a narrow strip, but sometimes extending inland into the fertile valleys and up the slopes of the hills and mountains a thousand feet or more in elevation. The groves are locally distinguished as the upland and the valley, or lowland, groves, though the term " upland groves " is often applied to trees planted on heavier soils irrespective of altitude and the term " lowland groves " to trees planted on lighter soils. On the north coast of Sicily the groves extend from Messina to Palermo somewhat irregularly, with a distinct break between Termini and Santo Stefano, where the mountains reach the sea, and beyond Palermo to a limited extent to Trapani. The principal lemon-growing center between Messina and Santo Stefano is Barcelona, with smaller centers around Bauso, Naso, Santa Agata di Miletello, and other smaller places. Near Palermo the most important districts on the coast are Bagheria and Ficarazzi. On the eastern coast there is an almost continuous narrow ribbon of groves close to the Strait of Messina, with inland valleys, like the Alcantara, reaching from Messina to Catania. In the Catania region, located on the lava beds of Mount Etna, the most important districts are Acireale, Giarre, Mascali, and Fiumefreddo. In the district extending northeast beyond Giardini the gardens are almost unbroken to Messina, the most important districts lying around Letojanni, Santa Teresa, Roccalumera, Galati, Tremestieri, and Gazzi, with Messina as the center from which the fruit and by-products are shipped. There is another district on the southeast coast around Syracuse, extending from Augusta to Avola, where it is less mountainous than in other parts of the island and where the industry is farther inland. Syracuse is the most important center of this region. The industry is developed most extensively in the province of Palermo, in which is located the Conco d'Oro, or the Place of Gold. This beautiful valley extends inland from Palermo to Monreale and is planted with several thousand acres of lemon groves and other fruits. Hardly second in the extent of the industry are the provinces of Messina and of Catania, with the provinces of Syracuse, Trapani, Caltanissetta, and Girgenti, mentioned in the order of their importance, containing fewer trees.

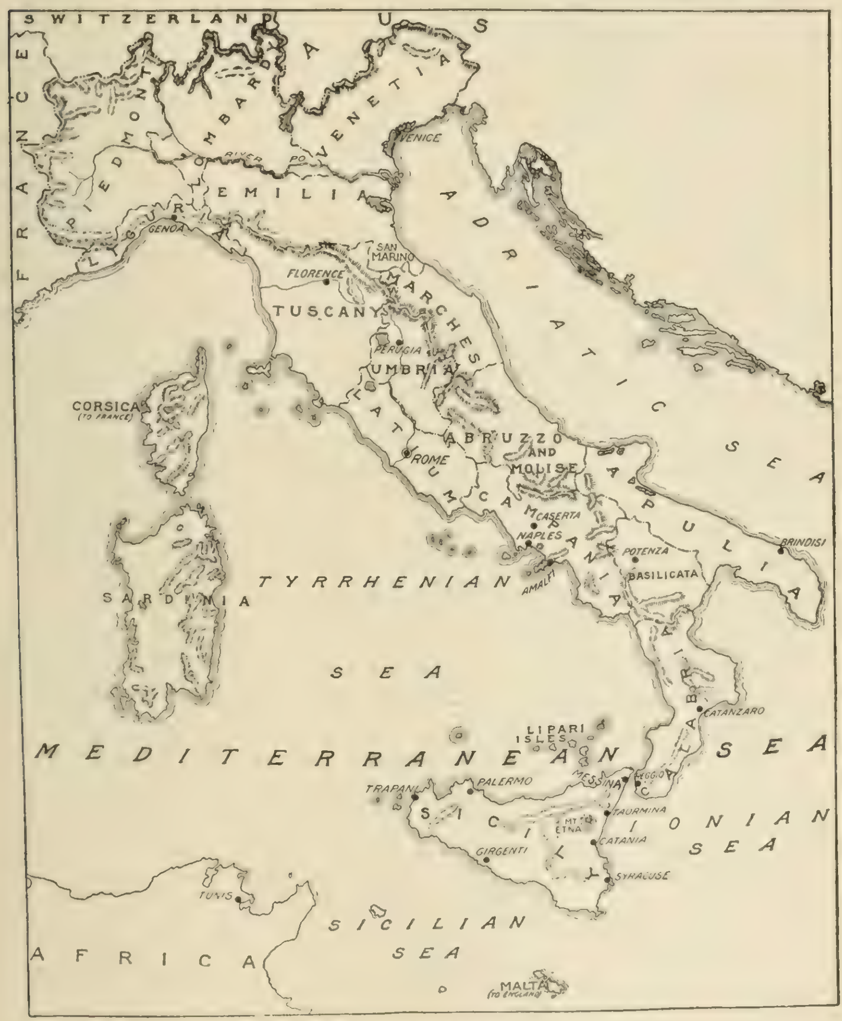
SWITZERLAND
AUSTRIA
FRANCE
PIEDMONT
LOMBARDIA
VENETIA
VENICE
RIVER PO
EMILIA
LIGURIA
GENOA
SAN MARINO
FLORENCE
TUSCANY
MARCHES
PERUGIA
UMBRIA
LATIUM
ROME
ABRUZZO AND MOLISE
CAMPANIA
CASERTA
NAPLES
AMALFI
POTENZA
BASILICATA
APULIA
BRINDISI
ADRIATIC SEA
CORSICA
(TO FRANCE)
SARDINIA
TYRRHENIAN SEA
CALABRIA
CATANZARO
LIPARI ISLES
MEDITERRANEAN SEA
MESSINA
REGGIO
TRAPANI
PALERMO
SICILY
MT ETNA
TAORMINA
CATANIA
GIRGENTI
SYRACUSE
IONIAN SEA
TUNIS
SICILIAN SEA
AFRICA
MALTA
(TO ENGLAND)

FIG. 1.—Map of Italy and adjacent countries.

The fresh fruit export industry centers in the province of Palermo, with the city of Palermo as the port of export. Before the earthquake in December, 1908, Messina was the center of the lemon oil, citrate of lime, and other citrus by-product industries. There was some fresh fruit exported from Messina before the earthquake, the exports going chiefly to European countries. There is also a limited shipment of fresh fruit and by-products from Catania and small shipments from Syracuse.

In 1898 the distribution of lemon trees in the provinces of southern Italy, including Reggio di Calabria and Sicily, was as follows:

Reggio di Calabria	1, 232, 765
Sicily:	
Messina	1, 634, 231
Palermo	2, 488, 475
Catania	828, 640
Syracuse	460, 125
Sicily—Continued.	
Caltanissetta	8, 210
Girgenti	56, 379
Trapani	216, 160
Total	6, 924, 985

The total number of trees in the provinces of central Italy in 1898 was 798,214, while in the northern provinces there were 564,559 trees, making a total of 8,287,758 lemon trees for the country as a whole. Detailed statistics since 1898 of the different kinds of citrus fruits in Italy are not available, but from the general data at hand it is probable that the number of trees in southern Italy has at least not decreased and has probably increased.

THE COMMERCIAL IMPORTANCE OF THE ITALIAN LEMON INDUSTRY.

From careful inquiries made by Dr. Arthur S. Cheney, the American consul who lost his life in December, 1908, in the earthquake at Messina, it was estimated that the crop of 1907 in Sicily and Calabria amounted to 6,900,000,000 lemons. It is estimated in Italy that one-third or more of the crop is usually converted into by-products, such as citrate of lime, lemon oil, and lemon peel, principally for export. Expressed in terms of boxes of 330 lemons each, the Sicilian and Calabrian crop would equal more than 20,000,000 boxes, or an equivalent of about 64,000 California carloads of 312 boxes each. The quantity that is converted into citrate of lime alone amounts to over 20,000 carloads of fruit, the product of 1907 equaling 23,000 pipes of 672 pounds each. It requires about 100,000 lemons, or the equivalent of nearly a carload of fruit, to make a pipe of citrate of lime. It is estimated by some Italian writers that nearly 2,000,000,000 lemons are required annually for domestic consumption, while the remainder of the crop, or a little over one-third of the total, is exported to different countries in the form of fresh fruit. These figures should be considered only as approximations of the extent of the lemon industry in Italy. The estimate of the domestic consumption is probably too high.

THE EXPORTS OF LEMONS FROM ITALY.

The exports of fresh lemons from Italy have increased more than 75 per cent in the last ten years, or from 325,000,000 pounds in the calendar year 1898 to more than 559,000,000 pounds in 1907. Of the total exports of fresh lemons, the largest proportion is shipped to the United States, it having received from 29 to 41 per cent of the exports annually in the last ten years, the proportion running above 35 per cent in six years out of the ten.

The United Kingdom has received from 17.7 to 25 per cent annually in the last ten years, and Austria-Hungary from 14.4 to 22.8 per cent annually. The remainder of the exports are distributed to Canada, France, Australia, Germany, Russia, and to various other countries in smaller quantities.

The following table, compiled from official statistics,[a] shows the exports of fresh lemons from Italy in quantity and in value during the calendar years 1898 to 1908, inclusive. The proportion exported to the United States has been determined from figures published by the same official source.

TABLE I.—*Exports of lemons from Italy, 1898 to 1908, inclusive.*

Calendar year ended December 31—	Quantity.	Value.	Exports to United States.	Calendar year ended December 31—	Quantity.	Value.	Exports to United States.
	Pounds.		*Per cent.*		*Pounds.*		*Per cent.*
1898	325,504,061	$3,419,486	41.3	1904	514,137,472	$3,600,745	37.3
1899	369,473,041	3,234,489	36.7	1905	452,903,655	3,171,899	32.1
1900	311,563,577	3,000,286	29.0	1906	550,524,096	4,337,525	37.1
1901	368,801,294	3,228,610	29.2	1907	559,549,378	4,408,653	37.8
1902	490,053,960	3,432,077	35.3	1908	540,332,790	[a] 4,257,229	32.7
1903	459,622,020	3,218,948	31.2				

[a] Value for 1908 in Italian trade statistics subject to revision in 1909.

THE IMPORTS OF LEMONS INTO THE UNITED STATES.[b]

The total imports of fresh lemons into the United States during the fiscal years 1898 to 1908, inclusive, practically all of which are received from Italy, are shown in the table following. The figures for 1908 represent the general imports, which are somewhat in excess of the imports for consumption. The reader should bear in mind that the figures from Italian sources cover calendar years, while the American figures cover fiscal years. They are therefore not comparable.

---

[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.

[b] United States Imports: Foreign Commerce and Navigation of the United States, Bureau of Statistics, U. S. Department of Commerce and Labor.

TABLE II.—*Total imports of lemons into the United States for consumption, 1898 to 1908, inclusive.*

Fiscal year ended June 30—		Quantity.	Value.
		Pounds.	
1898		133,347,050	$2,521,985.32
1899		208,634,448	4,399,160.72
1900		159,384,389	3,655,946.85
1901		148,334,112	3,516,877.29
1902		162,962,091	3,318,908.82
1903		152,775,867	3,087,244.22
1904	general tariff	164,042,415	3,507,679.55
	from Cuba	410	6.00
		164,042,825	3,507,685.55
1905	general tariff	139,079,003	2,904,975.44
	from Cuba	3,528	71.00
		139,082,531	2,905,046.44
1906	general tariff	138,689,148	$2,934,195.34
	from Cuba	1,122	26.80
		138,690,270	2,934,222.14
1907	general tariff	153,930,739	4,254,230.56
	from Cuba	34,519	1,236.00
		153,965,258	4,255,466.56
1908	general tariff	178,437,835	4,388,247.95
	from Cuba	21,298	393.00
		178,459,133	4,388,640.95

The general imports into the United States exceed in variable quantities the imports for consumption from year to year, as the imports for other countries, such as Canada, pass largely through American ports.

About 50 per cent of the total imports are received in the United States from May to July, inclusive, the heaviest shipments in recent years arriving in June. From 70 to 80 per cent of the total imports arrive from March to August, inclusive.

Of the imports of lemons into the United States during the last ten fiscal years, from 82.29 to 89.85 per cent of the total have been received in the customs district of New York; from 3.02 to 8.07 per cent of the total in Boston and Charlestown; from 1.67 to 9.44 per cent of the total in New Orleans; from 0.35 to 1.65 per cent of the total in Philadelphia; from 0.29 to 1.67 per cent of the total in Baltimore; and from 0.26 to 3.34 per cent of the total in other customs districts.

THE DISTRICTS FROM WHICH ITALIAN LEMONS ARE EXPORTED TO THE UNITED STATES.

The lemons exported from Italy to the United States are forwarded principally from Palermo, Messina, and Naples. The fruit shipped from these ports may not have been grown in the vicinity of the ports, as the exporters in one district frequently buy fruit in another and have it shipped in for packing. The exporters in Palermo, for example, may ship lemons from the districts of Messina or Catania which have been forwarded by rail to Palermo to be prepared for export at that point. When shipped, these lemons are recorded as Palermo fruit. The shipments from Naples include most of the lemons from Sorrento, from the Amalfi coast, and from other points in the Sorrentine peninsula.

The following figures, furnished by Mr. Victor L. Zorn, president of the New York Fruit Exchange, show the number of boxes of lemons from these districts received at the port of New York from 1903 to 1908, inclusive:

TABLE III.—*Boxes of lemons received in New York from Italian ports, 1903 to 1908, inclusive.*

Year ended December 31—	Ports of export.			Total.
	Palermo.	Messina.	Naples.	
1903	1,506,850	339,000	57,850	1,903,700
1904	1,581,500	316,900	71,950	1,970,350
1905	1,298,250	98,100	35,600	1,431,950
1906	1,468,800	159,100	75,600	1,703,500
1907	1,647,925	101,400	211,100	1,960,425
1908	1,625,525	85,250	117,350	1,828,125

From these figures it will be seen that from 80.2 to 90.6 per cent of the total exports of lemons to New York since 1903 have been forwarded from Palermo, from 4.6 to 17.8 per cent from Messina, and from 2.5 to 10.8 per cent from Naples. The shipments from Messina in the past have gone largely to Germany, Russia, Austria, Canada, Norway, and Sweden.

THE DISTRIBUTION OF FOREIGN LEMONS IN THE UNITED STATES.

The trade in foreign lemons is confined largely to the eastern half of the United States. In the territory west of the Missouri River, including central and western Texas, the trade is supplied almost exclusively with California lemons. In the Middle West, especially in the territory north of the Ohio River, where the competition between the domestic and foreign lemons is close, probably from 50 to 60 per cent of the lemons handled are imported from Italy. In the South Central States, including eastern Texas, the trade is supplied largely with Italian lemons distributed from New Orleans, and in the territory east of the Alleghenies the trade is supplied principally with foreign fruit distributed from New York, and in smaller quantity from the ports already mentioned.

THE METHODS OF HANDLING FOREIGN LEMONS IN THE UNITED STATES.

METHODS OF SECURING THE LEMONS.

The lemons imported into the United States are usually secured from Italian sources in one of four general business methods, which are believed to be stated in their order of importance as follows:

(1) The purchase of the fruit by the importer in America from the shipper in Sicily at a fixed price, generally including freight.

It is probable that at least half of the lemons imported are purchased by the importer in this manner. Purchases of this kind are generally made on letters of credit issued through an American bank, the letter of credit usually equaling a little less than the purchase price. The shipper and the buyer agree that the fruit shall consist of certain grades and sizes. In making the letter of credit the buyer includes the specifications covering the purchase, as, for example, 60 per cent first grade and 40 per cent second grade, and 50 per cent 300's and 50 per cent 360's, and specifies what proportion of the total payment is to be advanced. The shipper presents this letter of credit with a bill of lading to the correspondent of the bank issuing the letter after the fruit is loaded for shipment, the bill of lading specifying the grades and sizes covered by the letter of credit. The money is then paid by the bank to the shipper.

(2) The shipment of fruit on commission on the strength of an advance by the importer of an amount less than the market value of the fruit at the time of shipment. The advances vary from $1 to $1.75 a box, depending on the condition of the market. The financial transaction is handled through letters of credit, as just described.

(3) The shipment of the fruit for the joint account of the shipper and the importer. Under this method the shipper and the importer agree on a price that represents the cost of the fruit f. o. b. in Italy. The importer advances to the shipper through a letter of credit an amount usually about 25 cents less than the agreed cost price per box. When the fruit is sold, the profit or loss is shared equally by the importer and the shipper.

(4) The shipment on commission without an advance from the consignee in the United States. This method of shipment is limited in extent.

METHODS USED IN SELLING THE LEMONS.

The lemons imported are generally sold at public auction, soon after arrival at the port of entry, by companies who unload the cargo, prepare it for display on the pier or in the auction room, and sell it at public sale under fixed rules and regulations. Some lemons are received each year at the port of New York to be shipped to other points in the United States or to be forwarded in bond to Canada, and small quantities may be received at other ports, to be reshipped in the same manner.

New York is the principal selling point for the foreign lemons used in the eastern half of the United States, with the exception of the Gulf States and the adjoining territory, which are supplied from New Orleans. The fruit for the eastern and interior markets, distributed from New York, is usually purchased by the dealer through resident New York brokers, but occasionally the dealer attends the sale and purchases the fruit in person.

THE EXPORTS OF LEMON BY-PRODUCTS FROM ITALY.

The principal products made from the lemon are citrate of lime, essential oils, concentrated and raw lemon juice, and green or prepared lemon peel. The by-product business is confined largely to Sicily and Calabria. This business holds the same relation to the lemon industry of Italy that the evaporating industry holds to the apple industry of western New York and of other parts of the United States or that the canning and drying industries hold to the deciduous fruit business of California. It makes it possible either to convert the low grades of fruit into useful products or to use a variable proportion of the better grades of fresh fruit in this manner during the months when prices are low or when the foreign demand for fresh fruit temporarily decreases.

THE EXPORTS OF CITRATE OF LIME.

Citrate of lime, or calcium citrate, is the most important by-product of the lemon and is an intermediate product in the manufacture of citric acid. Citric acid is not made in Italy. The citrate of lime is exported to different countries and is there converted into the acid. The exports of citrate of lime from Italy have increased from about 3,000,000 pounds in 1899 to nearly 17,000,000 pounds in the calendar year 1908. The United States is the heaviest buyer of this product, having received from 32.5 to 40.7 per cent of the total exports from Italy in the last ten years except in 1904, when the proportion dropped to 26.8 per cent. France and the United Kingdom are the next heaviest importers, the quantities received sometimes nearly equaling the exports to the United States.

The table following, from Italian statistics, shows the total exports of citrate of lime from Italy during the calendar years 1899 to 1908, inclusive, with the percentage of the total exported to the United States:

TABLE IV.—*Exports of citrate of lime from Italy, 1899 to 1908, inclusive.*[a]

Calendar year ended December 31—	Quantity.	Value.	Exports to United States.	Calendar year ended December 31—	Quantity.	Value.	Exports to United States.
	Pounds.		*Per cent.*		*Pounds.*		*Per cent.*
1899	3,142,248	$151,296	32.8	1904	12,193,764	$1,067,483	26.8
1900	3,743,448	196,628	37.6	1905	9,096,050	875,929	37.9
1901	3,120,202	147,502	35.3	1906	11,353,362	1,292,085	40.7
1902	7,517,541	329,055	32.5	1907	13,598,990	2,142,902	34.6
1903	7,229,617	632,905	38.0	1908	16,997,856	[b] 2,678,489	31.3

[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.

[b] Value for 1908 in Italian trade statistics subject to revision in 1909.

THE IMPORTS OF CITRATE OF LIME INTO THE UNITED STATES.

The total imports of citrate of lime into the United States for the fiscal years 1894 to 1908, inclusive, are given in the table following:

Table V.—*Imports of citrate of lime into the United States for consumption, 1894 to 1908, inclusive.*[a]

Fiscal year ended June 30—	Quantity.	Value.	Fiscal year ended June 30—	Quantity.	Value.
	Pounds.			*Pounds.*	
1894	443,981	$52,137	1902	3,066,904	$293,293
1895	608,214	59,458	1903	2,657,110	240,466
1896	668,106	66,388	1904	2,926,529	274,130
1897	496,291	42,090	1905	3,444,344	355,728
1898	1,026,467	84,789	1906	3,903,234	534,977
1899	1,577,804	157,432	1907	3,872,924	726,626
1900	1,944,863	204,243	1908	3,853,105	580,293
1901	2,416,088	299,583			

[a] United States Imports: Foreign Commerce and Navigation of the United States, Bureau of Statistics, U. S. Department of Commerce and Labor.

THE EXPORTS OF ESSENTIAL OILS FROM CITRUS FRUITS.

The exports of essential oils of all citrus fruits, including lemon, orange, and bergamot, are usually lumped in Italian statistics. From 1900 to 1905, during which time the statistics were separated, the lemon oil comprised from 62.5 to 84 per cent of the total exports of citrus-fruit oils. The total exports have approximated 1,000,000 pounds a year during the last ten years. From 24.9 to 38.8 per cent of the total exports of essential oils have been sent to the United States during that period.

The following table, from Italian statistical sources, shows the total exports of essential oils of lemon, orange, and other citrus fruits from Italy for the calendar years 1898 to 1908, inclusive, with the percentage of the total exported to the United States:

Table VI.—*Exports of essential oils of lemon, orange, and other citrus fruits from Italy, 1898 to 1908, inclusive.*[a]

Calendar year ended December 31—	Quantity.	Value.	Exports to United States.	Calendar year ended December 31—	Quantity.	Value.	Exports to United States.
	Pounds.		*Per cent.*		*Pounds.*		*Per cent.*
1898	1,010,491	$1,150,003	24.9	1904	1,419,695	$2,485,697	38.3
1899	1,298,130	1,590,997	26.6	1905	1,292,136	2,262,358	31.1
1900	1,100,812	1,541,900	27.8	1906[b]	971,334	935,373	36.7
1901	1,101,504	1,398,226	28.1	1907[b]	1,034,816	1,358,870	41.5
1902	1,425,438	1,871,814	38.8	1908[b]	1,051,256	[c]1,380,458	33.2
1903	1,233,210	1,619,391	34.8				

[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.

[b] Since 1905 all the exports stated are lemon oil.

[c] Value for 1908 in Italian trade statistics subject to revision in 1909.

The quantity of lemon oil included in the exports shown above, from 1900 to 1908, inclusive, is given in the table following:

TABLE VII.—*Exports of lemon oil from Italy, 1900 to 1908, inclusive.*[a]

Calendar year ended December 31—	Quantity.	Calendar year ended December 31—	Quantity.
	Pounds.		*Pounds.*
1900	743,024	1905	840,417
1901	826,446	1906	971,334
1902	1,197,213	1907	1,034,816
1903	970,565	1908[b]	1,051,256
1904	886,990		

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[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.

[b] Value for 1908 in Italian trade statistics subject to revision in 1909.

THE IMPORTS OF LEMON OIL INTO THE UNITED STATES.

The following table shows the total imports of lemon oil into the United States for the fiscal years 1898 to 1908, inclusive:

TABLE VIII.—*Total imports of lemon oil into the United States for consumption, 1898 to 1908, inclusive.*[a]

Fiscal year ended June 30—	Quantity.	Value.	Fiscal year ended June 30—	Quantity.	Value.
	Pounds.			*Pounds.*	
1898	160,264	$117,021.00	1904	294,568	$174,649.00
1899	237,302	185,728.00	1905	310,056	175,852.00
1900	261,978	211,800.00	1906	370,270	218,749.00
1901	268,341	231,040.78	1907	487,717	423,133.00
1902	391,485	282,092.00	1908	440,326	592,533.00
1903	361,210	233,487.00,			

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[a] United States Imports: Foreign Commerce and Navigation of the United States, Bureau of Statistics, U. S. Department of Commerce and Labor.

THE EXPORTS OF CONCENTRATED LEMON AND CITRON JUICE.

The exports of concentrated lemon and citron juice, which are lumped together in Italian statistics, have decreased from about 5,000,000 pounds in 1899 to about 1,400,000 pounds in 1907. The United Kingdom and France are the largest receivers. The proportion of the total exported to the United States has varied from 1.1 to 10.6 per cent in ten years. In the last five years the proportion has varied from 5.6 to 10 per cent.

The following table shows the total exports of concentrated lemon and citron juice from Italy for the calendar years 1898 to 1908, inclusive:

Table IX.—*Exports of concentrated lemon and citron juice from Italy, 1898 to 1908, inclusive.*[a]

Calendar year ended December 31—	Quantity.	Value.	Exports to United States.
	Pounds.		*Per cent.*
1898	5,205,333	$273,415	8.0
1899	5,496,784	288,724	1.5
1900	4,407,921	231,531	5.3
1901	4,117,132	233,465	2.9
1902	4,989,941	270,838	1.1
1903	3,180,829	175,430	5.6
1904	4,728,694	$269,078	10.0
1905	2,462,019	150,339	6.0
1906	2,074,109	118,023	6.9
1907	1,443,146	94,753	7.5
1908	1,844,387	[b] 121,098	10.6

[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.

[b] Value for 1908 in Italian trade statistics subject to revision in 1909.

THE EXPORTS OF RAW CITRON AND LEMON JUICE.

The exports from Italy of raw citron and lemon juice combined have varied from 1,357,827 to 4,474,044 pounds in the last ten years. The proportion exported to the United States has varied from 4.1 per cent of the total, the lowest, in 1900, to 16.1 per cent, the highest, in both 1899 and 1902.

The table following, from Italian statistical sources, shows the total exports of raw citron and lemon juice from Italy during the calendar years 1898 to 1908, inclusive, and the percentage of the total shipped to the United States:

Table X.—*Exports of raw citron and lemon juice from Italy, 1898 to 1908, inclusive.*[a]

Calendar year ended December 31—	Quantity.	Value.	Exports to United States.
	Pounds.		*Per cent.*
1898	1,725,337	$18,125	11.3
1899	1,842,844	19,359	11.6
1900	2,307,137	24,237	4.1
1901	1,357,827	14,264	6.3
1902	2,250,919	23,646	16.1
1903	2,035,307	20,490	13.8
1904	2,322,790	$23,385	5.7
1905	1,883,409	18,961	9.9
1906	4,474,044	34,974	8.4
1907	1,872,606	21,311	10.9
1908	2,039,275	[b]23,208	....

[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.

[b] Value for 1908 in Italian trade statistics subject to revision in 1909.

THE EXPORTS OF LEMON, ORANGE, AND OTHER CITRUS-FRUIT PEEL.

The exports of lemon, orange, and other citrus-fruit peel, green or dried, which are combined in Italian statistics, have increased from 1,598,351 pounds in 1898 to 7,342,273 pounds in 1908. The proportion of the total exports shipped to the United States in the last ten years has varied from 0.2 per cent, the lowest, in 1900, to 6.2 per cent, the highest, in 1904. The heaviest importer is the United Kingdom.

The following table shows the total exports from Italy of lemon, orange, and other citrus-fruit peel, green or dry, during the calendar years 1898 to 1908, inclusive, and the proportion of the total exported to the United States:

Table XI.—*Exports of lemon, orange, and other citrus-fruit peel, green or dry, from Italy, 1898 to 1908, inclusive.*[a]

Calendar year ended December 31—	Quantity.	Value.	Exports to United States.	Calendar year ended December 31—	Quantity.	Value.	Exports to United States.
	Pounds.		*Per cent.*		*Pounds.*		*Per cent.*
1898	1,598,351	$34,981	0.6	1904	4,615,376	$101,011	6.2
1899	6,184,406	135,351	0.6	1905	3,737,496	81,798	1.9
1900	3,802,312	83,217	0.2	1906	5,859,885	128,248	1.8
1901	4,498,531	98,454	2.3	1907	5,475,179	119,829	1.6
1902	3,172,451	69,432	2.6	1908	7,342,273	[b] 160,692	....
1903	2,798,106	61,239	1.8				

[a] For 1907 and previous years: Movimento Commerciale del Regno d'Italia. For 1908: Statistica del Commercio Speciale di Importazione e di Esportazione del 1 Gennaio al 31 Dicembre, 1908.

[b] Value for 1908 in Italian trade statistics subject to revision in 1909.

A glance at the figures shown in the foregoing tables brings out clearly that the two most important items of the Italian lemon industry, namely, the export of fresh fruits and citrate of lime, have increased steadily in the last ten years. The essential-oil business has remained nearly stationary, the exports of concentrated lemon and citron juice have decreased, the exports of raw juice have not varied widely, while the exports of citrus-fruit peel have shown wide variation and on the whole have increased.

The relation of the United States to the Italian lemon industry is brought out in the figures. Over one-third of the fresh fruit has recently been shipped to the United States, about one-third of the citrate of lime, and one-third, more or less, of the essential oils.

THE RATES OF DUTY ON LEMONS AND THEIR BY-PRODUCTS ENTERING THE UNITED STATES.

Under the tariff act of 1897 the rate of duty on lemons entering the United States is 1 cent per pound. Under the reciprocity treaty with Cuba, December, 1903, the tariff was made 1 cent per pound, less 20 per cent on fruit from that country. The tariff on citric acid is 7 cents per pound, the imports of which in 1908 were 171.795.6 pounds, valued at $62,804. Citrate of lime and lemon oil are entered free of duty. There is no duty on lemon and orange peel not prepared, but there is a duty of 2 cents per pound on similar material preserved, candied, or dried, the imports of which in 1908 were 613,834.5 pounds, valued at $40,342.

THE SEASON OF LEMON RIPENING IN ITALY.

There is a wide variation in the season of ripening of the lemons of Italy and an equally wide variation in the character of the fruit from different sections, as well as in the fruit that is harvested at different periods of the year in the same section.

The lemon season is considered to begin on October 1 in Italy and ends on September 31 following. The earliest fruit ripens in the Syracuse district, where the first picking is made from October 1 to 15. The harvesting in the Catania and in the Messina districts begins about ten days later than in Syracuse. The Palermo harvest commences from December 1 to January 1, and occasionally by November 1. The soil is heavier in this district and the fruit can be held on the trees longer than in other districts. The fruit on the Sorrentine peninsula, including the Amalfi coast, is the latest to ripen, the harvest beginning about February 1. There is also a summer crop of lemons in the Messina and Catania districts, called the "Verdelli" lemon. The methods of producing this crop will be described later.

The harvesting season in each district covers a period of seven to ten months, more or less, depending on its character. The heaviest yields of each locality usually occur during the second, third, and fourth months in the season, though in some regions, like Palermo, where the altitude and soils are variable, the fruit may be harvested practically throughout the year. The fruit gathered in the first harvest in each section is somewhat inferior in keeping quality, usually on account of its immaturity and irregularity in condition. The fruit harvested in December and January is supposed to have the best keeping quality, and considerable fruit was stored before the earthquake in the Messina district in cellars for shipment in March or April to European markets, especially to Russia, Austria, Norway, and Sweden. Practically no stored fruit is shipped to the United States, though small quantities are sometimes sent to Canada. The fruit harvested in October and during the period from May to September, inclusive, is practically all used for export. That harvested from November to April, inclusive, is used principally in the manufacture of by-products, with some of it entering the export trade as fresh fruit. In the Palermo district the heaviest exports to all countries occur from March to July, in the Messina and Catania districts from November to February, and on the Sorrentine peninsula from June to September.

THE CHARACTER OF THE LEMONS IN DIFFERENT REGIONS OF ITALY.

There is a wide variation in the character of the fruit grown on different soils and in different regions. The lemons produced on the lighter soils are rougher in texture and poorer in quality than the lemons from the heavier lands. They ripen earlier and are said to have poorer keeping qualities. The soil along the eastern coast is generally gravelly and light in texture, except in the upper valleys between Messina and Giarri. Only a small proportion of the fruit harvested near this coast, that cut in October, and the Verdellis are exported; the rest of it is converted into by-products. On the other hand, from 80 to 90 per cent of the firm, finer textured fruit in the upland valleys on the same coast is generally used for export. There is often a difference of 50 to 75 cents a thousand in the price paid for the upland or heavier land lemons in comparison with the fruit grown on the lighter soils near the coast. The fruit grown on the north coast of Sicily enters largely into the export trade. Probably as much as 90 per cent of the lemons of the Palermo district is exported, two-thirds of the exported fruit going to America. Of the total exports from the Messina district less than one-half is usually sent to America, the rest of the fruit going to European markets, especially Germany, Russia, Austria, Norway, and Sweden, with lesser quantities to Australia and Canada. The fruit in the Palermo district is smaller and better in texture than the lemons from Messina. While the crop at Messina averages two-thirds of the 300 lemon per box size, not over one-third is usually of that size in the Palermo district, the 360 size predominating in the latter section.

THE CHARACTER OF THE LEMONS EXPORTED TO DIFFERENT MARKETS.

Of the lemons exported to the United States, a large proportion are of the highest grades, that is, the finest in texture and free from blemishes. Of the fine-textured lemons the sizes packing 300 and 360 to the box are shipped largely to the United States, the 300 size predominating in the shipments to the northern markets and the 360 size in the exports to the southern districts. The largest lemons, the 200 size, predominate in the shipments to England. The English markets receive large quantities of the coarser grades of fruit. The German markets take a large lemon, but smaller than England. France takes a lemon medium to small in size, similar to the United States, and uses a good deal of coarse fruit, while a 330 size is frequently sent to Russian markets, this size including a mixture of

300 and 360 lemons. The size of fruit shipped to a country depends somewhat on the form of the duty existing in that country. Where the duty is based on weight, the medium to small sizes are generally exported; where it is based on the number of lemons the large sizes are exported.

TERMS APPLIED TO LEMONS RIPENING AT DIFFERENT PERIODS.

There are several terms applied to the lemons that ripen at different periods in Italy, though the terms are not always applied consistently to the same kind of fruit. The lemon trees bloom normally in April and May in southern Italy. There may be more or less blossoming through the year, and the terms are usually applied to the fruit that results from the blossoms that appear in different seasons.

The term "Limoni" is applied to the main crop of fruit maturing from the normal flowers of the preceding season.

The term "Maggiolini," or locally "Bianchetti," is applied to the fruit that ripens in April and May and which is produced from irregular bloom following immediately after the normal blooming season. The Maggiolini lemons are somewhat light in color. They are high-grade fruits and are largely exported.

The term "Bastardi" is applied to large irregular lemons, usually flattened at the ends. The texture of the skin is medium in quality, and it adheres firmly to the flesh. The fruit is acid, generally seedless, and is produced from blossoms that appear irregularly late in the season. The Bastardi lemons usually ripen in August.

The term "Basterdoni" is often applied to the largest Bastardi lemons. They ripen in September.

The term "Verdelli" is applied to a crop of lemons that ripens in the summer. The crop is produced artificially by withholding the water from the trees during June and July. About the first of August the trees are stimulated by a quick-acting fertilizer and an abundance of water. Two weeks later the trees begin to bloom and the fruit is harvested during the following summer.

THE VERDELLI LEMONS.

The Verdelli lemons are of enough importance to warrant a special description. In producing the crop of these lemons the object is to have the fruit mature in June or July, during the season of highest prices. They are usually grown not oftener than every other year in the same grove, as an annual production is said to be detrimental to the vitality of the tree, but on some of the lighter soils the Verdellis are produced annually. The Verdelli crop is produced principally in the region between Messina and Giardini, on the east coast of Sicily, though the system is practiced to a limited extent in the districts on the northern coast. The crop of Sicily matures with the later part of the normal crop of the Sorrentine peninsula.

METHOD OF PRODUCTION.

On the heavier soils the earth is removed from the base of the tree about June 1 until the larger roots are exposed to a depth of a foot in a diameter of 6 to 10 feet. On the sandy soils the earth may not be removed from the roots. No water is applied to the trees for sixty days. At the end of the drying-down period the foliage is wilted, but is not supposed to have begun to shed. The aim then is to stimulate the tree to the greatest possible extent. This is accomplished by adding a quick-acting fertilizer, like composted manure, or a chemical fertilizer, usually of sulphate of ammonia, at the rate of 2 to 2½ pounds per tree. Occasionally nitrate of soda is used. The manure or fertilizer is mixed with the soil that was removed from the basin, or it is dug into the sandy soils where the basins are not made. The basins are then filled with the soil and the fertilizer, and water is applied around each tree once a week, or oftener if the soil absorbs it, for a period of two or three weeks. If the tree responds, the blossoms begin to appear with the new growth in two weeks, and the old foliage gradually drops off.

It is easier to produce the Verdellis on the lighter soils and on young trees. Sometimes the trees, especially in the older groves, do not respond to the treatment. If the weather is cool and there is an abundance of dew following the blooming season, the young lemons may be killed by the wet, wilted blossoms which adhere to them for some time. Under these conditions the old blossoms are often removed by beating the branches with poles. It is quite common to produce a Verdelli crop on a grove which failed to set a satisfactory crop in the spring.

THE LEMON GROVES OR GARDENS OF ITALY.

The lemon gardens of Italy are variable in size. The majority contain not more than a few trees or a few acres each at most. There are some groves of several hundred acres each in the territory between Messina and Catania and in the Palermo district, a few of the largest plantings amounting to 1,500 to 2,000 acres. The larger groves are usually under the direct management of the owners, while the smaller ones may be worked by the owners or by tenants who lease them from the owners or from one who already holds a lease.

The trees in the gardens on the Sorrentine peninsula, and to a lesser extent in other sections, are frequently planted irregularly, without reference to their position in rows or to the distance apart. This is especially true of many of the gardens in the rough lava beds on the slopes of Etna, in the Catania district, where the lemon trees are often planted in small walled-up pockets containing a dozen or more trees. In other sections where the areas of adaptable land are larger the trees are planted with regularity. There is a wide variation in the distance apart of planting the trees. In Sicily and in Calabria they vary from 12 to 18 feet apart each way; on the Sorrentine peninsula and in the vicinity of Naples, from 8 to 12 feet, and in the districts farther north the trees are planted even closer together. The yield of fruit also varies widely. In the well-cared-for irrigated groves of Sicily the trees bear from 800 to 1,200 lemons each, and sometimes an unusually well-handled grove produces from 1,200 to 2,000 lemons per tree. On the Sorrentine peninsula, where there is a short water supply and where the trees are planted closer together and are smaller, the average is not over 400 lemons per tree, while the yields are still smaller in the gardens farther north.

HANDLING THE LEMON GARDEN.

PROPAGATION.

There are no extensive nurseries in Italy where lemon trees are grown as they are in the United States. The stocks of bitter orange (*Citrus bigaradia*) are usually grown by the owners in small seed beds under the bearing lemon trees. The bitter orange grows wild in Sicily and in the mountains of Calabria, and is now used universally as a stock on account of its resistance to the gum disease, which devastated the groves of Sicily about thirty years ago, when the trees were propagated on lemon stocks.

The orange seeds are sown in the spring in a well-prepared bed, and the seedlings are usually transplanted when a year old at a distance apart of 10 inches or a foot in small clumps under the bearing trees or in distinct areas. When the trees reach a diameter of 1 to 2 inches and a height of 5 to 6 feet they are transplanted to the garden or grove. They may or may not have been budded or grafted with the desired type of lemon before transplanting. The lemon bud is usually inserted from 2 to 3 feet from the ground and the top of the lemon tree is started from 4 to 6 feet from the ground. As the trees grow older the lower shaded branches die and, like the apple trees of the eastern United States, the main branches lose the lower bearing wood and the tree becomes increasingly high headed and spreading. In many of the old groves in Sicily the lowest fruit-bearing branches are from 6 to 10 feet from the ground. A high-headed grove is shown in Plate II, figure 1, while a low-headed lemon grove in California is shown in Plate II, figure 2, for comparison. Many of the closely planted lemon trees are irregular in form in both trunk and top, the trunks of many of the trees assuming a crooked, almost tortuous, outline.

While the lemon trees are young it is a common practice to grow cereals or vegetables between the rows. This crop may be grown by the owner or by the tenant, or the land may be sublet to a second or third party for this purpose.

PRUNING.

The lemon trees of Italy are not pruned systematically as they are in California. Pruning in Sicily means the cutting out of dead wood and the shortening of the vigorous suckers every year or two, and the opening of the top when the tree becomes dense. The object of pruning is similar to the general practice of pruning orange trees in California, though much more roughly done; an ax is often used in cutting out the wood. No system of pruning has been developed the purpose of which is to hold the tree low headed, to modify the density of the tree, to stimulate the production of new bearing wood, or to modify the growth of the bearing wood in different parts of the tree. The growers generally believe that the low, dense-headed tree produces a tender, poor-keeping lemon and that the scale insects and diseases are much less serious in the trees with the high, open, spreading form which admits the air and sunlight to the greatest extent.

TILLAGE.

The tillage of the Italian lemon groves is practically all done by hand labor; occasionally it may be done in the larger groves with oxen and a primitive one-handled plow, though plowing in the lemon groves in Italy is a rare operation. The land is generally turned over from 5 to 10 inches deep with a short, heavy hoe twice a year, in February or March and again in September, and twice lightly, 3 inches or more deep, in May or June and in November, to turn under the weeds. The relation of tillage to the conservation of moisture and to the liberation of plant food is not understood.

FERTILIZING.

The principal fertilizer used in the lemon groves is composted sheep, goat, or cow manure. Chemical fertilizers have come into use to a limited extent in recent years. Sulphate of ammonia is the principal source of nitrogen, with nitrate of soda used to a less extent; sulphate of potash and ashes are used chiefly for potash; and bone meal, slag, and ground rock are among the sources of phosphoric acid. The commercial fertilizers have been experimented with in recent years in connection with cover crops and with manure. Several factories have been organized in Sicily for the manufacture of commercial fertilizers.

There is no definite system of fertilizing used by the Italian lemon growers. There seems to be the same lack of exact knowledge among the growers as to the fertilizer requirements of the trees as there is among the lemon growers of the United States. There is no agreement as to the kind of fertilizers or the quantity to use, or the time or method of application. The fertilizer that is advocated most plausibly is likely to be used most generally, and different growers using different kinds of fertilizers are likely to get equally good results if the land is kept in good physical condition. All are agreed that the trees need to be fed liberally, though they are not fertilized as regularly or to the extent practiced by the growers of California.

There is a general agreement among the growers that the physical qualities of the soil must be maintained by the frequent use of manure or by turning under a cover crop of weeds. As in California, some of the growers have an impression that stable manure makes the fruit coarse in texture and of poorer keeping quality. The manure is applied generally in the spring, but sometimes in the fall. It is dug into the irrigating basin around the tree or in the bottom of the irrigating furrows. In some groves the manure is applied in the basin around the tree every other year, and, in the years between, farther away from the tree in the bottom of deep furrows, in order to reach the fine, distant feeding roots. It is not practicable to discuss the fertilizing question further, as there is an endless variation in the methods of application and in the quantities of manure and commercial fertilizer in use. The variation in the quantity of manure per tree will run from 40 to 150 pounds, and in chemical fertilizer from 2 to 10 pounds, depending on the nature of the fertilizer, the condition of the trees, and the general practice of the grower.

IRRIGATION.

Irrigation is practiced more or less in most of the lemon-producing sections of Italy. There is said to be an abundance of water in many parts of Sicily, but no comprehensive system of water development or of commercial water management, such as the California citrus-fruit growers have developed, has been attempted in Italy. Water is therefore likely to be scarce in dry seasons. In the fall of 1908, following a prolonged drought, the groves on the Sorrentine peninsula and in many parts of Sicily were suffering from lack of water. The landowner may lead the water from the mountains in terra-cotta pipes to reservoirs or wells on his place, or the water may be distributed directly from the mountain supplies to the groves. The excess water not needed by the large landowner is sometimes distributed in canals to tenants or independent landowners who purchase the land and a right to the water from him. In other sections the water may be pumped by the grower from dug wells located on the place. The water is sometimes raised in bucket pumps driven by steam power, but more often by oxen operating a windlass. It may be distributed directly from the pump to the land or pumped first to a reservoir and distributed later by gravity flow.

The water is distributed in the groves in a variety of ways. Usually there are brick or terra-cotta tile ditches in which the water is carried to the heads of the rows. A few cement ditches, similar to those used in the groves in southern California, have been constructed in recent years. If the land is sloping, a main furrow is run between the rows at right angles to the ditches mentioned. The water is run from the ditch into this furrow and is led out to a square basin constructed around each tree or around two trees, or to short side furrows in place of the basins under the trees. The basins are shown plainly in Plate II, figure 1. The method of distributing the water in the grove depends on the nature of the land, its contour, and on the supply of water. The basin system of irrigation is used when the water supply is comparatively abundant. The furrow method is more economical of water. The distributing furrows are made by hand or occasionally with a plow after the spring cultivation, and the basins are formed by banking up the earth, as shown in the illustration (Pl. II, fig. 1). In some sections where the winter rainfall is excessive the basins and ditches are reshaped in the fall to carry off the excess of water not absorbed by the ground.

The irrigating season begins in Italy in April or May and ends in September or October, depending on the ending and the beginning of the rainy seasons. The rainfall in Sicily is more abundant than in southern California, the annual rainfall in the Messina district for ten years past, according to data gathered by the late Doctor Cheney, amounting to 30 to 40 inches.

Cultivation, however, is not practiced in Italy to conserve moisture. The land is not hoed after each irrigation, and the loss of water from evaporation is large. The bearing trees are flooded every week or two on the sandy soils, and every two or three weeks on the heavier land. On the heavier soils around Palermo some of the growers irrigate the trees only when the foliage begins to wilt. Under such conditions the trees may not be irrigated oftener than three times during the season.

PROTECTION AGAINST FROST.

Occasionally the Italian lemon crop is badly injured by frost, especially when the trees are in bloom in April or May. The temperature on the mainland on the Sorrentine peninsula generally drops below freezing every winter, and it often freezes in Sicily. In the former section an elaborate system of trellises is built over many of the groves, and mats of straw or of fine chestnut twigs are used to cover the trellises from November to April or May, when the mats are removed. Occasionally they are rolled up and are left on the trellises during the summer. On the Amalfi coast, where the lemons are grown on terraces one above the other, the trees on each terrace are covered with a trellis from 8 to 10 feet in height, as shown in figure 2. The new wood is not allowed to grow above the trellis, but the fine wood and smaller suckers are tied to it once a year. The strong-growing suckers and the excess of wood are pruned off. The tree assumes a flat, umbrella shape, as shown in figure 3, and the lemons hang down and are largely picked from beneath the trellis. This form of tree training produces a partial shade, and the lemons growing in it are comparatively fine and smooth in texture. As the trees bloom late in the spring, the fruit matures largely in the summer months. The fruits known in the market as the "Sorrento" or the "Majori" lemons are grown under this system. No systematic attempt is made to protect the groves against frost by the use of fires or smudges.

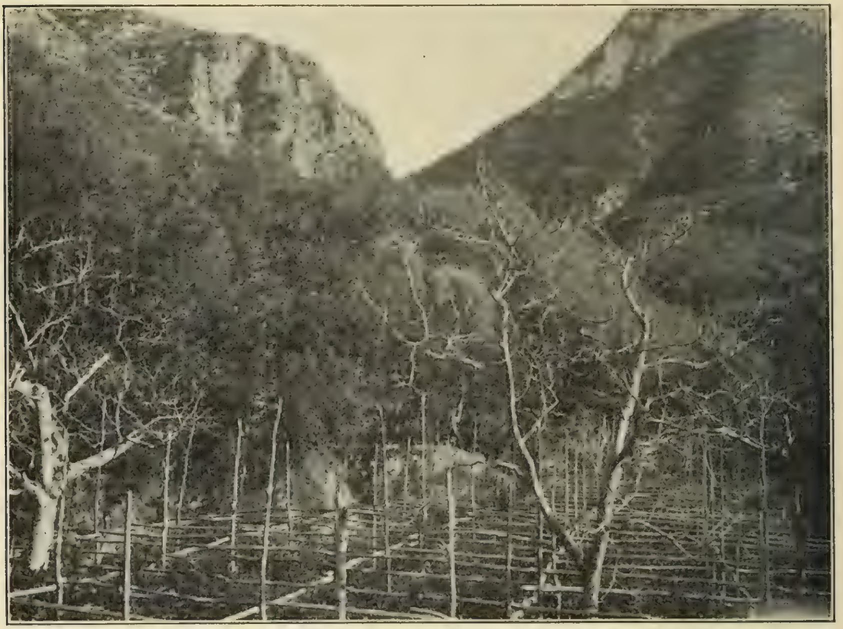

FIG. 2.—A trellis over a lemon grove. Walnut trees are growing through the trellis. Straw mats are fastened to the trellis for protection from frost from November until April or May.

HANDLING THE LEMON CROP.

SELLING THE FRUIT.

There are several methods of selling the lemon crop in Italy. Practically none of the fruit is exported by the grower except occasionally in the case of large, experienced producers. There are no cooperative handling or marketing agencies similar to the marketing organizations that have been formed by the California lemon producers. The grower sells his fruit usually through a broker to the exporter or to the manufacturer of by-products. The broker acts as an agent for both parties in the final settlement of the transaction, often shipping the fruit for the grower, receiving the money, and depositing it or using it in purchases for the grower, as there are few business transactions between the producer and the Italian business man, on account of the bargaining that must be done before a sale of fruit is made.

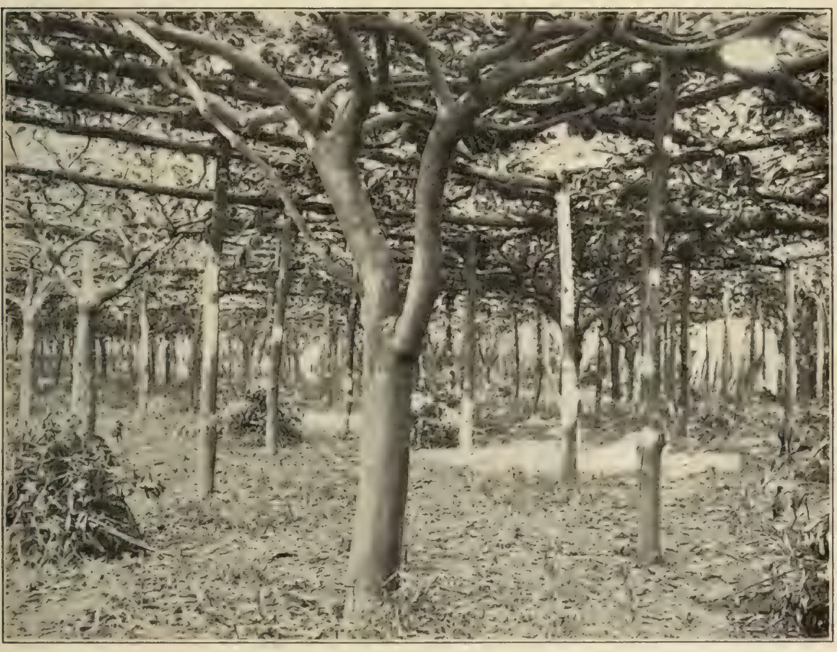

FIG. 3.—Lemon trees growing under a trellis, showing the flat, umbrella form of the trees caused by tying down their branches.

The lemon crop may be sold by the grove as a whole for the season, the purchaser taking all the fruit, or each picking may be sold separately by the thousand lemons, a thousand, as understood in the Italian industry, meaning 1,040 lemons, weighing 120 kilos, or about 260 pounds. In the by-product districts of Syracuse, Messina, and Catania the crop is generally sold as a whole for the season or, to a lesser extent, at an agreed price per thousand lemons for the crop of the season. In the upper valley or highland regions of the same districts, where the lemons are finer in grade and better for export, the fruit is usually sold by the thousand lemons at each picking. In the Palermo district the fruit is generally sold by the thousand at each picking or, to a less extent, by the thousand for the season, or as a whole crop on the trees. The buyer usually picks the fruit when it is sold by the season. The grower usually picks it when sold at each picking. In the Messina district considerable fruit is brought to the city by the growers to be sold there either through a broker or directly to an exporter or manufacturer. The price paid the grower for the fruit has varied from $1.50 to $3.50 per thousand in the last few years.

The handling of the lemon crop of Italy previous to the season of 1908 was based on a system of money advances extending from the exporter of the by-product or the fresh-fruit handler down through the various parties through whose hands the fruit or by-product passed until it reached the producer. The advances were made before the fruit was harvested, usually at the time of closing a contract between the parties having to do with the product in question, to defray the operating expenses of the different parties. The system had grown to such an extent that each party in a series of transactions became a banker for the next lower party depending on him financially. An attempt was made to abandon the system before the season of 1908 by the exporters of by-products, with the result that the lemon trade was in an uncertain and demoralized condition when these observations were made in September. Contracts for by-products and for fresh fruit had not been made with the producers at that time on account of the uncertain market conditions in foreign countries, and at least a year's supply of citrate of lime that had been bought at high prices was on hand in the Messina district. Many of the producers who previously had made contracts earlier in the season and had received an advance on the contract were in need of financial assistance at that time. The citrate of lime in the Messina district is said to have been destroyed by the earthquake.

METHODS USED IN THE GARDENS.

On account of the broad-spreading, high-headed trees it is necessary to use ladders in picking the lemons. The fruit is placed in padded baskets. From the picking baskets the fruit may be placed in larger padded baskets, in which it may be carried out of the grove to the packing house. On the Amalfi coast it is common to see women carrying the baskets of lemons from the groves to the packing houses, often a distance of several miles.

If to be used for by-products, the lemons are pulled from the trees. If the fruit is to be used for export or for export and by-products, the picker, generally a man, breaks off the stem with the thumb and finger, leaving a stem attached to the fruit an inch or more in length. For export a man can pick about 5,000 lemons a day; for by-products, from 8,000 to 12,000. The fruit is picked by size, as in California.

If the fruit is to be used in a by-product factory, it is drawn there in bags or in baskets loaded into donkey or ox carts.

The fruit that is used both for export and for by-products may be taken to a packing house on the place, where the stems are cut close with shears by either men or women. It is then roughly graded by women into export and by-product fruit, the rough lemons and low grades going for the latter purpose. Sometimes, as shown in the picking scene in Plate III, figure 1, the stem clipping and grading is done in the grove. In this case the lemons are piled on straw, the stems are cut short, and the fruit is roughly graded, after which the export fruit is delivered to the packing house on the place or, if near by, to the packing house of the exporter. On the Amalfi coast the lemons are often drawn in hand carts from the groves to the packing houses. The women carry the lemons out of the high groves in covered baskets to the carts and then draw them to the packing houses. When the fruit is packed on the place it is allowed to wilt for two or three days or longer, after which the lemons are wrapped, generally by the women who grade them. The packing is done by men. The boxes are then delivered to the packing house of the exporter, where the fruit is always regraded before shipping.

METHODS USED IN THE PACKING HOUSES.

The handling of the fruit after it reaches the packing house is simpler in some ways than the American method of lemon handling. The sweating or coloring of the lemons is not practiced, and none of the fruit is washed. The lemons are comparatively clean as they come from the tree. The fruit hangs too far from the ground to be affected with brown-rot, if the disease exists in Italy, and the lemons are not covered with the dust arising from cultivation and from a loose soil, as the California fruit is likely to be. If the lemons are dirty, they are sent to the by-product factory. The fact that the exported lemons are not washed probably adds to the keeping quality of the fruit after it reaches the market.

Comparatively few of the Italian lemons are stored. The bulk of the fruit is shipped soon after picking, only the best grades entering the export trade to the United States. There may be from three to five grades selected for export to different countries. The tree-ripe lemons are shipped to other countries or are used in making by-products. The quick shipment of the fruit that corresponds only to the silver-green or the light-yellow lemons of California probably adds to the keeping quality of the Italian lemons. The dark-green, as well as the tree-ripe fruit, is not considered of good enough keeping quality to be shipped to the United States.

The methods of grading and packing Italian lemons are more complicated than the American methods. If the fruit has not already been wilted in the garden, the lemons are generally allowed to stand a few days on arrival in the house, either in the packages or in piles on the floor. There are many differences in the details in handling the fruit in the packing houses. The packing-house operations are not systematized to the extent practiced in American houses. In a house in Palermo the lemons were in a pile on the floor 3 feet deep or more, probably containing a thousand boxes. The fruit had been roughly graded by the grower, but it was regraded by the exporter. The grading was done by women. Other women wrapped the fruit, twisting the wrapper at both ends of the lemon except the fruit for the top tiers of the box, which is wrapped after the American method. The wrapped lemons were then placed in baskets. The fruit was of the 300 and 360 sizes. The lemons of one size were then placed in the boxes by boys as rapidly as the men who do the packing could place them in position in the box. In the United States the packer sizes, wraps, and packs the fruit. In Italy the packer's work is concerned only with arranging the fruit in the box. A good workman will pack 70 boxes a day.

The interior of a packing house in Catania is shown in Plate III, figure 2. The padded bins are used in grading, sizing, wrapping, and packing the fruit. The method of packing differs from that followed in America principally in the double twist on the wrapper and in the use of bright-colored pictures on the wrappers and often on the paper that is used in lining the boxes; also in the use of shredded paper, gold and silver colored tinsel, etc., for embellishing the package. There have been several sizes of boxes in use in the export trade, but an effort is being made to use for the United States boxes similar in size to the California box.

In the Messina district considerable of the fruit of the November and December crop is stored in cellars for export to European markets in the spring. The fruit is wrapped and packed in boxes before storage. When ready for export the decayed fruit is removed and the fruit is regraded and rewrapped. The losses that occur from blue mold are recognized by the shipper to be due principally to the rough handling of the fruit before it is stored; an unwrapped lemon stored under these conditions would shrivel slightly and lose the fine texture of the skin. The very green fruit picked in October is not considered of good storing quality, as it may shrivel while in storage, while the fruit maturing in January and later loses in keeping quality as the harvesting season progresses.

THE COST OF PRODUCING LEMONS IN ITALY.

It is difficult to obtain accurate figures on the cost of producing a crop of lemons in Italy on account of the variable conditions under which the fruit is grown and the lack of information on the part of the growers themselves. No attempt will be made in this publication to give an itemized statement of cost. An observer may easily gain widely different impressions by questioning producers who work under different conditions and in different parts of the country. In the fall of 1908 the wages of labor used in the groves in different parts of Sicily and on the mainland varied from 40 to 70 cents a day of ten hours. The usual price was about 50 cents a day; a higher figure was found only rarely. In the packing houses the men were paid from 50 to 60 cents a day. A man with a team of oxen was paid $2 a day. The women were paid from 30 to 40 cents a day and occasionally as high as 70 cents, and the boys from 20 to 30 cents. In some sections the daily wage includes a bottle of wine. Where this occurs the wine represents the equivalent of about 6 cents in the wage and is deducted from it. Previous to 1908 the wages were lower, but there is said to be a growing scarcity of labor in Italy on account of the heavy emigration and it was expected by all classes of business men that there would be a further advance in wages in the future.

A fair estimate of the cost of producing a crop on a bearing grove, including cultivation, irrigation, fertilization, pruning, and other operations up to the time of picking, is from $25 to $60 per acre, though the latter figure is unusually high. This does not include taxes or interest on the investment. This estimate is based on the cost of producing the fruit in the larger, well-managed groves. The cost is less in the groves that are not so well managed. In one of the large groves in the Alcantara Valley, near Giardini, the cost of cultivation and pruning in 1908 was 10 cents a tree, fertilizing 10 cents, and irrigation 2 cents, making a total of $25 per acre for 100 trees. This grove was representative of the better groves on the eastern coast of Sicily. The cost of production will probably not equal more than one-half as much as the cost in the United States.

The cost of handling the fruit from the tree to the point of shipment is equally difficult to estimate. It is fair to assume that the cost of the labor used in the different operations will not equal one-half the cost of similar labor in the United States. The investment in the equipment of a packing house is smaller than in California. These general statements are based on the comparative wages paid in the two countries and not on the efficiency of the labor. The Italian lemon box costs about the same as the American box. The freight rate on lemons, per box, from Sicily to New York or Boston was 1s. 3d., or 31 cents, in the fall of 1908. The box is estimated to weigh 82 pounds.

II.—THE BY-PRODUCTS OF THE LEMON IN ITALY.

By E. M. Chace, *Assistant Chief of the Division of Foods, Bureau of Chemistry.*

INTRODUCTION.

The relative importance of the industry which has to do with the utilization of the by-products of lemon culture is controlled, as a whole or in any single district of Italy, by several well-defined factors. Of these, the quality of the fruit is of the greatest importance, for in regions where it is uniformly good the problem of the disposal of the few culls is solved by local consumption. In other regions, however, the nature of the fruit itself practically prohibits its exportation, and it is here that the so-called "by-products" become the source of the chief industry of the district. Where there is any question of the purpose to which the fruit is to be put, the anticipated profits will be the controlling factor and the relative price of citrate of lime and lemon oil will be compared with that of the fresh fruit.

The price of labor and conditions of transportation are also important minor factors, as it is manifestly less costly to sort and pack the fruit than to transform it into oil and citrate, but, on the other hand, it is less difficult to transport these final products than the original fruit, which requires such careful handling and is subject to decay. The financial condition of the operator is also a factor, for the by-products offer a more tempting field for speculation, citrate of lime keeping indefinitely, while large quantities of the oil remain over from crop to crop. Lastly, local custom plays a much more important part than would be possible in this country. Changes in methods of operation are much more conservatively received, and the working classes as a whole do not adapt themselves so readily to new tasks.

GEOGRAPHICAL DISTRIBUTION OF THE BY-PRODUCT INDUSTRY.

In northern Italy one or more of the factors mentioned render the production of by-products unprofitable and it is not until the southern part of the southernmost provinces of the mainland is reached that this branch of the industry begins to flourish. Across the straits of Messina in Sicily it reaches its zenith, and along the southeastern coast of that island it is the principal resource of the people.

In the province of Calabria another essential-oil industry shares the attention of growers and materially lessens both the lemon culture and the production of lemon oil; the manufacture of citrate of lime, however, is relatively increased, as it is also a by-product of bergamot culture. The world's supply of bergamot oil for the manufacture of perfumes comes exclusively from this comparatively restricted region, so that much higher prices are obtained for it than for lemon oil, which has to compete with the output of Sicily. It has been estimated by competent Messinese brokers that only a small percentage (certainly less than 5 per cent) of the total lemon oil production comes from this region.

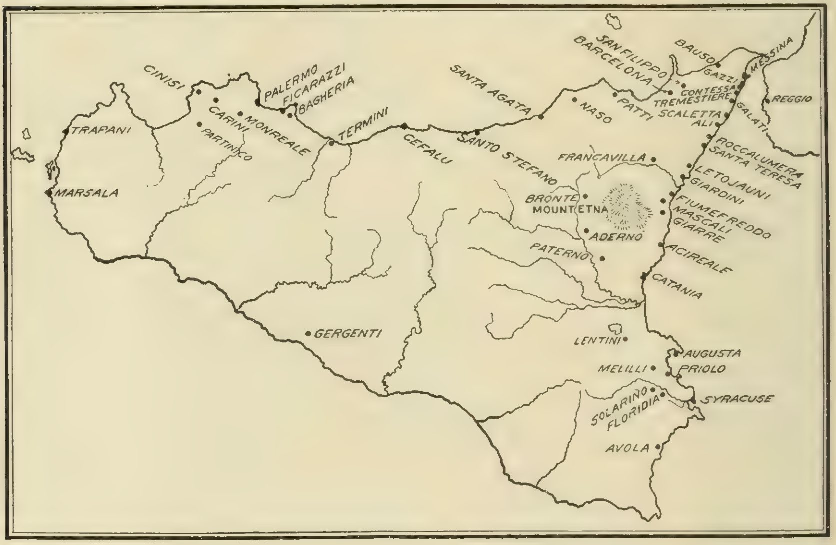
CINISI
PALERMO
FICARAZZI
BAGHERIA
TRAPANI
CARINI
MONREALE
PARTINICO
MARSALA
TERMINI
SANTA AGATA
CEFALU
SANTO STEFANO
SAN FILIPPO
BARCELONA
NASO
PATTI
BAUSO
GAZZI
MESSINA
CONTESSA
TREMESTIERE
SCALETTA
ALI
GALATI
REGGIO
ROCCALUMERA
SANTA TERESA
LETOJAUNI
GIARDINI
FRANCAVILLA
BRONTE
MOUNT ETNA
FIUMEFREDDO
MASCALI
GIARRE
ADERNO
PATERNO
ACIREALE
CATANIA
GERGENTI
LENTINI
AUGUSTA
MELILLI
PRIOLO
SOLARINO
FLORIDIA
SYRACUSE
AVOLA

FIG. 4.—Map of Sicily, showing the regions where lemon by-products are prepared.

The adjacent island of Sicily, separated from the mainland by only a few hundred yards at the nearest point, is the largest lemon-growing region of the world. Here the lemon-producing belt lies along two sides of the triangular coast line, interrupted with few exceptions only in the spots where the hills advance into the sea. This belt is naturally divided into four parts, and one of these is best divided again in districting the island. A map of Sicily showing the by-product regions is shown in figure 4.

THE INDUSTRY IN THE ETNA DISTRICT.

The Etna district begins on the south at Catania, a city of considerable importance, second in size in Sicily, around it being clustered several important gardens from which arises considerable trade in both fresh fruit and by-products. The former is exported principally to Austrian ports, while the by-products go to Messina for exportation. The city contains but one lemon-oil factory of considerable size, but many smaller ones are situated in the suburbs. These latter places are crowded into the narrow streets and alleys under the most sordid conditions, the fruit being prepared in the street and the oil extracted in the living rooms and stored in the sleeping quarters of the house. The only place given over exclusively to the manufacturing process is the room devoted to the citrate of lime, and even this often serves as a stable. These operators buy a few culls from day to day, every member of the family taking part in the work of converting them into the final products.

In this district the next center farther north is Acireale, a small thriving city, the most important of the by-product industry in the Etna district. There are a dozen or more factories here, and it is also headquarters for the Essential Oil Producers' Association, an organization of comparatively recent formation, the membership of which seems to be confined to producers in the Etna district.

North of Acireale, 6 miles distant, is Giarre, with one factory of fair size and several of minor importance. About 2 miles nearer the foothills of Mount Etna, at the railroad station for Mascali, is a small village called Carrubba, whose inhabitants, men, women, and children, are employed in a group of large factories situated there. One of these factories is the largest and best equipped in Sicily, employing at the height of the season over 300 hands, producing several hundred pounds of oil a day. Even here the advances which have been made do not seem to have changed the character of the methods employed, the improvements often seeming more apparent than real, and being certainly greatly emphasized by the crude conditions surrounding them.

Mechanical carriers are used for conveying the fruit from one part of the factory to the other and for carrying off the waste products, but no devices for halving the lemons or removing the pulp from them have been attempted. A battery of machines for extracting the oil from the peel had, however, been installed, but later abandoned. It is not strange that the device was a failure, for the peel required the same preparation as in the present methods of handling, and each machine needed an attendant, who handled separately every half lemon rind. As the rate of production was not greatly increased, the apparent saving was the difference in cost between the hire of a boy or girl attendant and that of a man sponger minus the cost of power necessary to operate machines. After all, however, the place is exceedingly well equipped when compared with other Sicilian factories, having cement floors and tanks, an electric lighting plant, steam ovens for drying citrate of lime, and many other improvements not usually seen on the island.

The two neighboring factories are of the usual type, but well arranged and roomy, employing about 50 hands each. They produce in the neighborhood of 100 pounds of oil daily.

Several miles northwest of this point, on the first of the foothills of Mount Etna, is the town of Mascali, containing several small factories of minor importance, drawing their fruit from the upland valleys of the vicinity. The other two centers in the district are Fiumefreddo and Giardini. The former contains several factories of a daily capacity of 50 to 100 pounds of oil; the latter, one large factory and several very small ones; there being in addition several small places between the two towns. Giardini is the northern limit of the district and draws its supplies from the south, being cut off from the Messina district on the north by a steep range of hills, over which hauling is difficult even on the fine military road which skirts the coast. Fiumefreddo is 6 or 7 miles farther south and is surrounded for miles on all sides by lemon gardens. The whole region from Catania to Giardini lies at the foot of Mount Etna, many of the fruit orchards being on its decomposed lava beds.

Oranges are also grown in this district, but are as a rule farther inland in the foothills. Aderno, Paterno, and Bronte, situated well up on the slopes of Etna, have considerable of this trade, as has Francavilla, farther north, nearer Giardini, the large factory at the latter place producing considerable quantities of both sweet and bitter orange oil from the fruit grown here.

The season begins in the Etna district in December and is practically over by April 1, although a few small operators continue into May. As the growing of Verdelli lemons is less practiced in this region than in the Messina district or in parts of the north coast, the inducements for summer work are not the same. The output of the district is marketed at Messina, being shipped to that point by rail, the exportation of oil and citrate of lime from Catania being less than the production of that city alone.

THE INDUSTRY IN THE MESSINA DISTRICT.

The Messina district, the second largest in Sicily, is practically a continuation of the Etna district on the south. The lemon-producing land lies along the coast, extending into the few valleys which run back between the hills as in that district. The soil, however, is probably quite different, as it is much farther from Mount Etna, no lava streams having entered the section for many hundred years.

The largest center at the southern end of the district is Santa Teresa, from which the oil of the neighboring town Roccalumera is also shipped. There are eight or more factories in the two places, one of which is considerably above the average size, employing a hundred hands or over, the others varying from those employing less than a dozen to those which have upward of fifty. Northward toward Messina, the next center of importance is Scaletta Zanglea, where are located three or four factories of very small size. At the northern end of the district, from Galati to Messina, the coast belt is much narrower than toward the south; the towns here stretch continuously along the military road, there being scarcely a visible boundary between them. When riding along this road the whole region seems an extension of the city of Messina.

The chief centers are Galati, Tremestieri, Mili, and Contesse, all small towns having direct railroad connections with the city. The factories are, taken as a whole, better equipped than elsewhere in the island. All are of moderate size, some employing less than twenty hands, while one, with over two hundred, is second or third in size in Sicily. This factory is one of the very few to produce concentrated oil by fractional distillation of the usual product. Owing to the size of the factories and the narrowness of the coast strip here, a large quantity of the fruit consumed is drawn from farther south, and during the bergamot season from Calabria, on the mainland.

Messina itself is hemmed in on all sides by high hills upon which no lemons are grown; fruit in large quantities must therefore come from some little distance. For this reason there is but one factory of any considerable size in the city; it employs, however, over two hundred hands, being situated on the north side of the city in an isolated group of gardens.

Messina, like Catania, contains many very small places where oil is made in the dwellings of the lower classes, the output in any single instance being small, but the total of some importance. There was also at one time a quantity of by-products produced here from the culls of stored fruit; this practice has, however, almost ceased at present, as storage fruit has given way before the Verdelli lemon.

On the north coast, not far from Messina, are two centers of minor importance, Bauso and Rometta. There seems little reason for classing them with the remainder of the Messina district except for the fact that they employ methods of production similar to those used on the south coast, while the center nearest them on the north coast employs a somewhat different process in obtaining oil. Undoubtedly, however, as far as the oil is concerned its composition here is more nearly like that of the north coast, no matter what process is used in its production. The factories in these towns are quite small, especially at Rometta, Bauso containing one of the average size, employing nearly fifty hands.

As in the Etna district, the produce of the entire Messina region is disposed of through Messina brokers. The season also is the same as in that district.

THE INDUSTRY IN THE PALERMO DISTRICT.

Palermo, the third district of importance, is the most westerly of the five. As in the other north-coast regions, lemon cultivation occurs in large isolated groups of orchards, with the exception of the Conco d'Oro, where the whole valley is given up to it. This valley is of exceptional fertility, and it is said that at one time considerable sugar cane was raised here. The fruit being above the average quality, the greater part of it is shipped fresh. The culls for by-products go both to Palermo and to the small city of Monreale, beautifully situated above Palermo in the hills. Here are some half dozen poorly equipped factories of small size, employing from a dozen to thirty hands each.

Palermo itself is the largest city of Sicily and contains several important factories, situated largely in the suburbs; the output of oil is not, however, larger than that of some of the small towns of the south coast. Information about the factories here is much harder to obtain than in other parts of Sicily; there are at least six of average size, the city being free from factories of the smaller type such as are found in Catania and Messina.

Toward the east, the principal center is Ficarazzi, where there are several factories, one of which may be said to be large. There are also other towns to the west of Palermo which contain manufacturing plants, but they are small and relatively unimportant. At Partinico, on the Trapani railroad line, are two or three, at Carini one, and at Cinisi another; taking it all in all, they are the crudest of the island.

While this district produces a large quantity of oil and citrate of lime, the industry is not so well developed as in the two districts already described, these commodities here being in every sense of the word by-products.

The production of summer lemons is universal in this region and affects to a considerable extent the composition of the essential oil. This is probably due to admixture of oil produced from the Verdelli lemons left upon the trees until the following season. Ordinarily the amount thus produced is small; when, however, the price of summer fruit is low it is very often left unpicked until the following natural crop is gathered, when it is sorted out with the other culls. In some factories this fruit is discarded, no attempt being made to produce oil from it. In the majority of cases, however, it is worked up as usual. It would seem that the former is far the better policy, as the yield both of oil and of citrate of lime are extremely low, added to which is the further disadvantage of the inferiority of the resulting oil. Where this fruit forms a considerable proportion of that from which it is being produced the resulting product is not marketable except in admixtures with normal oil.

The season begins here later than in any of the other districts, often two months later than at Syracuse, and extends later into the warm weather, the month of June often finding several factories still in operation. Although this district contains the largest seaport and city of commercial importance in Sicily in the city of Palermo, only a comparatively small quantity of the by-products is shipped from that point, this exportation going to England, that coming to the United States being confined to fresh fruit.

THE INDUSTRY IN THE SYRACUSE DISTRICT.

The fourth by-product district is on the opposite side of the island, southeast of Palermo, and is but slightly less important than that center. The Syracuse district differs in many ways from the others of Sicily; the country not being mountainous, the fruit is cultivated farther inland than usual and the problem of irrigation is more difficult. Lemon culture is not the chief occupation here, for the country was one of the finest wheat-growing regions of ancient times, and at present besides this cereal both almonds and grapes are extensively cultivated.

The climate is very mild, the gathering of lemons beginning several weeks earlier than in the other districts. October 15 to April 15 is a liberal estimate of the manufacturing season, while fifteen days might be cut from each end and more nearly represent the actual fact.

The district contains several isolated centers of production, the gardens not being continuous, as in the lemon belt proper, but clustered in large groups about the several towns. Three of these centers are of considerable importance, the cities of Syracuse, Floridia, and Avola, all containing six or more factories and each employing 20 hands or more.

At Syracuse there are no factories on the island which forms the old city, all being on the mainland in the newer suburbs. Comparing favorably in size with the average factories in other districts, they are in equipment above those at Palermo, but not so well equipped as those near Messina. Floridia is some 12 miles inland from Syracuse, situated in a very fertile valley of lemon groves, the half dozen factories here varying in size, two being of considerable importance; all are, however, devoid of mechanical improvements. The output of this town is carted to Syracuse, as it has no railroad connections.

South of Syracuse city no lemons are grown until Avola, 15 miles distant, is reached. Here is situated another large group of orchards; the factories, as usual clustered about the town itself, are below the average size and have no special equipment. Some orange oil is prepared in this district and large quantities of peel are dried and sold for the preparation of the liqueur curacao.

The other centers in this district are Augusta, with one factory of average size; Priolo, with two small places; and Melilli, with one. Augusta is 18 miles north of Syracuse, on the coast, and is the center of the salt industry; Priolo is between Syracuse and Augusta, some miles from the railroad, while Melilli is farther inland, situated well up in the low hills.

The lemon products of the district find their way to market through Messina, with which there is direct railroad connection.

THE INDUSTRY IN THE NORTH-COAST TOWNS.

The remaining district to be considered is the heterogeneous collection of towns on the north coast. Here, again, as in Palermo and Syracuse, the cultivation of the lemon takes place in isolated groups of orchards around the central towns, the country being very mountainous and having no cultivated strip of coast land, as on the south. The fruit is grown in the valleys between the spurs of hills, all of the large towns being near the Messina-Palermo railroad line, which winds along the seacoast.

By far the most important center, in fact the only important one of this region, is Barcelona, a small inland city not far from the seaport of Milazzo. Here are some three factories, employing from 30 to 50 hands each, and a few more of smaller size, all without mechanical equipment. The methods employed are, as has been stated, similar to those of the Palermo district, the old method of production being used and distilled oil manufactured from residues.

The small city of Patti, the next largest by-product center, is west of Barcelona, 2 miles from the railroad station of the same name. There are but two factories here, both employing approximately 30 hands and, as at Barcelona, producing considerable sweet and bitter orange oil.

Farther west there are no other factories until Capo d'Orlando is reached, at which place are several of small size, which is also the case at Santa Agata di Miletello. The factories in all of these places use the so-called new or two-piece method of manufacture, which is peculiar, inasmuch as they are situated between two larger districts using the other method. At Santa Agata di Miletello the factories do not produce citrate of lime, the lemon juice being concentrated in copper kettles and sold to liqueur and bitters manufacturers in northern Italy.

The commerce of the north-coast towns, as far as lemon by-products are concerned, is carried on through Messina, although there is a thriving local seaport town, Milazzo. While the district covers a much greater territory than that covered by either the Palermo or Syracuse districts, it produces less oil and citrate than either. The season is more nearly like that of the Palermo district, although manufacturing begins somewhat earlier and ceases sooner than in that district.

MANUFACTURE OF BY-PRODUCTS.

There are two chief by-products of lemon culture—the essential oil of lemon and citrate of lime; besides these, lemon peel in brine and concentrated lemon juice are of lesser importance. Oil of lemon is used very largely for flavoring purposes. It finds application also in perfumes and to a limited extent in pharmaceutical preparations; the greater part of that imported into this country, however, is used in the preparation of the ordinary extract of lemon, well known to every housewife. Citrate of lime, or, more properly, calcium citrate, is an intermediate product in the manufacture of citric acid. In the lemon juice itself the acid occurs in the free state, together with sugars and mucilaginous bodies. It is in order to free it from these that it is combined with lime, for the compound thus formed is insoluble and precipitates from the juice, being finally separated by filtration. This product must then be again treated in order to free it from lime and obtain the citric acid once more in the free state. There are no factories in Sicily for this purpose, although the Italian Government was, before the recent earthquake, making efforts to establish a plant by subsidy. The product is now shipped to Germany, England, and the United States, where the lime salt is decomposed with sulphuric acid, filtered through boneblack, and crystallized from solution in water. The process is one of some difficulty, considerable loss arising from the decomposition of the citric acid by the sulphuric acid present.

The salting of the lemon peel is usually confined to those districts of Sicily where the towns are upon the seacoast situated near sloping beaches, so that sea water is easily obtainable. It is not usually packed in the interior, although a few towns near Messina have some little trade in this line, the product being repacked in that city. Producers in Sicily claim that there is a demand for three separate kinds of stock; first, that from which no oil has been removed; second, that which contains approximately half the oil; and, lastly, a completely exhausted product. All classes are consumed in the bakers' and confectioners' trades. Where the rinds are to be used for packing, the lemons are divided lengthwise, the pulp removed in the usual way, and the peel packed by hand as firmly as possible in large hogsheads, which are afterwards filled with sea water and reenforced by the addition of salt.

The production of concentrated juice is not extensive, the factories being small and the methods of evaporation extremely crude. In those at Santa Agata di Miletello the juice is pressed from the pulp and filtered, as in the manufacture of citrate of lime, and then pumped into shallow tanks supported over a crude fireplace. Here evaporation takes place over a wood fire until the required consistency is obtained, this point being ascertained by cooling a portion of the juice and inserting a spindle. The final product, a very dark semisirup, of acid, bitter, and smoky taste, is sold to liqueur and bitters producers in northern Italy. Besides the two factories at Santa Agata di Miletello, there are one or two on the Calabrian mainland. Altogether the industry is of minor importance.

EQUIPMENT OF BY-PRODUCT FACTORIES.

It has already been hinted that in the great majority of cases the factories in Sicily are very poorly, even crudely, equipped, the nature of the operations which take place requiring but very simple apparatus. In the preparation of oil, machinery is not used except in the few factories which are situated in Calabria.

For the manufacture of citrate, a crusher, as shown in Plate IV, figure 1, a filtering device for juice and another for citrate, a precipitating tank supplied with a heating coil, an oven or heating room, and a small juice pump only are necessary. This apparatus is usually arranged to fit into quarters originally intended for other purposes; the crusher and filter presses on substantial foundations near the room where the cutting of the fruit takes place, near the latter a juice tank and pump, while the precipitating tank is also near by, as the pumping is usually done by hand in the heating room wherever convenient.

In many of the smaller factories a loft is floored off and the space thus provided used for extraction of the oil, the room often being scarcely 6 feet high in the center, dark, and ill ventilated. On the north coast, where the work takes place at night (from midnight to 8 or 9 o'clock in the morning), this place also serves as sleeping quarters for the sponge men. The custom of preparing the oil at night seems confined to the Palermo and north-coast towns. The explanation given for this method of operation is that the sunlight has a deleterious effect upon the oil, but a more probable cause is the fact that the sponging operation can take place at night with less trouble than any of the other processes in by-product manufacture and that the same workmen can thereby work during both daylight and darkness.

PREPARATION OF THE FRUIT.

The preparation of the fruit differs somewhat in the different districts, and while the variation seems slight it undoubtedly affects the length of the operation and perhaps the quality of the oil produced. In the Syracuse, Etna, and Messina districts and in Patti and Santa Agata di Miletello, north-coast towns, a method known as the "two piece" is used. In Palermo and Barcelona the process used is called "three piece," although some factories in the latter city use the other method. The difference between the two lies in the manner of removing the rind from the fruit. In the former the lemon is halved and the pulp removed from these halves; in the other the peel is pared off in three longitudinal strips. The three-piece method of preparing the fruit is shown in Plate V, figure 1. When the fruit arrives at the factory it is dumped into large bins, around which sit the cutters, who divide the lemons in halves or pare them, according to the method used. An ordinary cheap kitchen paring knife is used for this purpose, the operators being women, girls, and boys on the south coast; on the north coast women and children are seldom employed. The work is carried on very rapidly where the fruit is halved crosswise, the lemon being cut and tossed into the tub with a single motion of the arm. Where the peel is to be salted down, the fruit is divided from end to end, and the time consumed is relatively longer, as is also the case where it is pared. The next step in the process is naturally omitted where the latter method is used. The half lemons are thrown upon shallow troughs, on each side of which stand the operators provided with baskets for holding the peel. The instrument used consists of a sharp, slightly concave disk firmly fastened on the end of a stout sickle-shaped wire, provided at the opposite end with a wooden handle. The disk is skillfully slipped between the pulp and rind of the lemon, held in the left hand, and forced toward the end with a circular motion of both the instrument and fruit. When sufficiently far advanced, a quick jerk removes the pulp, the separation being complete and the rind unbroken.

The operators are usually paid by the basket of resulting peel, the women making from 20 to 40 cents a day, while the children, who do the cutting, rarely make over 15 cents, often as low as 5 cents. Where the lemons are pared the separation is much less complete, there being always considerable pulp left on the rinds and some little rind at the ends of the pared fruit. As a result of this, some little lemon juice becomes mixed with the extracted oil, and after the extraction of the oil from the peel the latter has to be mixed with the fruit pulp in order not to lose the considerable portion of the part of the fruit clinging to it.

EXTRACTION OF THE ESSENTIAL OIL.[a]

In both methods of operation the peel is thrown into large wicker baskets, which, when full, are dipped into a reservoir of cold water and thoroughly shaken to remove the excess. This washing is said to wilt the rind and render a complete extraction of the oil possible. However this may be, it is certain that fruit treated in this manner and allowed to stand for several hours yields relatively more oil than that worked up immediately after separation from the pulp. At this stage, the pulp and peel having been separated, the former is sent to the crusher to be converted finally into citrate of lime, the latter to sponge men, who extract the oil.

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[a] See also the article by the same author, entitled "The Manufacture of Flavoring Extracts," in the Yearbook of the Department of Agriculture for 1908, pp. 333-342.

The extraction or sponging process is not essentially different with the different forms of peel, the operators sitting upon low stools with an earthenware bowl between the feet, a pile of peel in front of them, and a basket for the exhausted material at one side. The bowl is about a foot in diameter, provided with a deep lip, directly beneath which is a small, round, concave depression which serves when the bowl is tilted forward, in pouring out its contents, to hold back the settlings of juice and precipitated matter. Across the top is placed a stick so notched as to fit tightly on the sides; resting upon it are the sponges, which differ somewhat according to the manner of preparing the peel. Where the fruit is cut crosswise, a large, flat sponge is surmounted by a smaller concave one, shaped somewhat like a brimless slouch hat, the half lemon being placed within this sponge when pressed. When the lemon is cut in the other direction, a large, heavy sponge rests upon the flat one and the fruit is pressed, colored side down, into it. This method is also followed where the rind has been pared from the fruit. With the first method the half rind is held in the right hand between the thumb and first two fingers and inserted in the wide aperture of the concave sponge, whereupon the latter is pressed upon with the left hand, the weight of the body being thrown into the motion. The pressure is relieved, the peel turned partly over with the right hand, and the pressing repeated. The same operation is carried on once or twice more, the rind thus receiving three or four pressings. Where the concave sponge is not used, the peel or slices are pressed face downward on the other sponge with the right hand, the left being used to keep the sponge in place, the same amount of force and number of pressings being required in either case.

The sponging process is somewhat varied where the three-piece method is used, owing to the quantity of pulp left adhering to the rind. A shallow, glazed bowl is placed upon the one ordinarily used and the notched stick fitted to it so that the mixture of juice and oil is received directly here. At the end of the operation the sponges are thoroughly squeezed out by hand and the lemon oil separated from the juice by tilting forward the glazed bowl over the other and violently blowing the breath upon the surface of the mixture until the oil has been carried over into the lower bowl. In this operation some juice and residue are found mixed with the oil, and this is separated finally in the larger bowl by carefully tilting forward and repeating the blowing operation. The small amount of juice and residue now present is caught by the depression in this bowl and the oil is received in a measuring bottle. The operation where the two-piece method is used is very similar; the oil and what little moisture and residue are extracted are caught in the earthenware bowl and separated as indicated.

The oil in either case is allowed to settle for twenty-four hours or longer, filtered through paper, and stored in large copper containers; that made by the three-piece method is said to keep longer without becoming turbid.

TREATMENT OF THE RESIDUES.

The treatment of the residues resulting from both methods is different; with the two-piece method they are passed through a conical cloth filter and the oil and water received in an earthenware bowl, where they are separated in the usual way. The filter is tied at the top and placed under a hand press, where the last traces of oil and water are expressed. The residues from the three-piece process, which are relatively greater in amount than by the other method, are placed in small copper stills, diluted with water, and distilled. The still is made in two parts, the pot being about 2 feet high, narrowing abruptly to a 3-inch aperture at the top, over which the condensing part fits tightly, the joint being cemented each time with clay. The latter part is a basin, whose straight sides are continued a short distance beyond the concave bottom, after which they converge similarly to the sides of a funnel. It is provided with two spouts, one of which enters under the bottom into what becomes the condensing chamber of the still; the other enters above and is used to draw off the water placed in the basin in order to cool the vapor coming in contact with it during the dis-

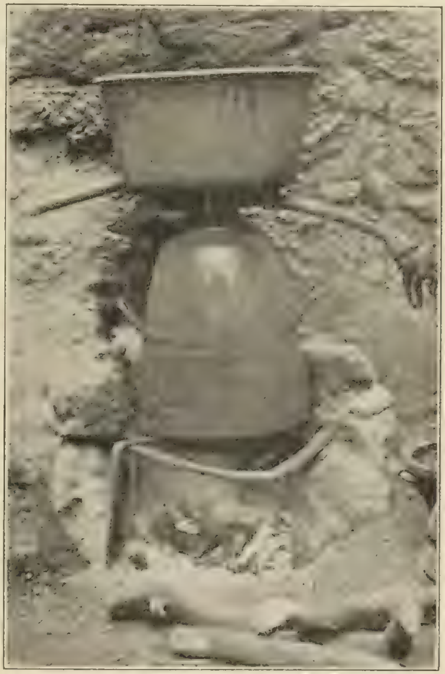

FIG. 5.—A lemon-oil still used on residues, Palermo. The oil produced is inferior to the hand-pressed product.

tillation. The condensation is further aided by wrapping the other spout with rags, over which the attendant pours cold water from time to time. A still is shown in figure 5.

The oil obtained by this process is water white, of disagreeable odor and abnormal chemical characteristics; having no sale in the pure state it is invariably mixed by either producer or broker with the hand-pressed product. The filtration method undoubtedly gives the best results, for if the residues are treated immediately the resulting oil can scarcely be distinguished from the original. Distilled oil is produced only at Barcelona and Palermo; in all other districts the residues are filtered.

MACHINE-MADE ESSENTIAL OIL.

The manufacture of lemon oil by machine is confined to the mainland of Italy, in the province of Calabria. As has been said, large amounts of bergamot oil are made here, and it is with the machine used in this industry that lemon oil is produced. The bergamot is shaped more like an orange than a lemon, being nearly round, so that the apparatus has to be slightly modified in order to use it on the latter fruit. The modification consists in removing the flat disks and substituting concave ones for them.

The machine itself, shown in Plate VI, figure 1, consists of a stand supporting two upright arms united by a crossbeam at the top. On the inside of one of these uprights is hung a large cogged wooden fly wheel geared against a cylinder, the sides of which are upright spokes fitting into the cogs of the fly wheel. To the under side of this cylinder is bolted a corrugated disk, shown in Plate VI, figure 2, fitted so as to revolve above a like stationary one at the bottom of the machine. An arrangement for raising and lowering the upper disk is provided for by an arm fastened to the cylinder and extending over a crosspiece at the rear. This arm is so weighted as to regulate the pressure brought to bear upon the fruit which is placed between the upper and lower disks. When it is lowered, the upper disk is raised and the lemons, which must be of uniform size, are placed within. The lever is then raised, lowering the disk upon the fruit, and the outside fly wheel is turned by hand. After two minutes it is stopped and the fruit removed, each lemon being carefully wiped off with a sponge. The grated rind and oil are received in a large pan set beneath the machine and subsequently filtered through cloth filters, the residue being placed under hand presses to express the last traces of oil and moisture.

Oil manufactured in this way is not in the least inferior to the hand-pressed product and has the added advantage of a much richer color, being used chiefly for the purpose of bringing up the color of the latter. The machine is not used on lemons until after the close of the bergamot season, fruit ripening before that time being sold to Sicilian buyers.

CITRATE OF LIME.

After the pulp of the lemon has been removed from the rind it is conveyed to a crusher, sometimes power-driven, but in a vast majority of factories run by hand. A crushing machine is shown in Plate IV, figure 1. The ordinary type consists of a hopper leading into wooden rollers and a small chute for carrying off the crushed pulp, the whole being placed over, or very near, a juice tank, into which the drippings flow. The crushed pulp is shoveled into large, circular, straw filtering mats and pounded down firmly with wooden rams. These mats are closely woven of coarse straw and have a circular opening at the top; after being filled they are placed one upon another in stacks of 4 to 12 under hand presses of large size. The presses are set, often by the aid of a windlass, and the combined pressing and filtration proceeds until the flow of juice ceases, the presses being set down several times during the operation. A press and filtering mats are shown in Plate IV, figure 2. The juice is led into the juice tank, from whence it is pumped, usually by hand, into a large vat provided with suitable heating arrangements consisting of direct fire, steam coil, or, in one or two instances, leading steam directly into the juice. In this tank the acidity of the juice is neutralized by means of lime water, the point of neutrality being ascertained by the use of litmus paper, and after heating for several hours the juice is run off into the filtering tank while still hot. The latter tank is provided with a false bottom of wooden latticework, over which is spread a special filtering cloth; the citrate of lime, which is deposited in a voluminous white powder, is retained by this cloth, while the waste liquor runs through and is discarded. When this liquor has sufficiently drained off, the deposit is shoveled into a small filtering bag and placed in stacks beneath a small press, where the excess is further removed. It is usually readily removed from these sacks to iron pans in which it goes to the drying oven. This oven is a small room, ventilated at the top, around the sides of which are built tiers of iron frames for holding the pans. In the center of the room is a gigantic charcoal burner, which supplies the heat for the evaporation, from six to forty-eight hours' drying being necessary, depending upon its size. The thoroughly dried cake, containing over 60 per cent of citric acid, is broken into small pieces and packed in hogsheads holding about 675 pounds each. An interior view of a by-product factory is shown in Plate V, figure 2.

The method of disposing of this product is very similar to that used with essential oils; small or large lots are offered to brokerage firms, accompanied by a certificate of analysis showing the actual content of citric acid. Exportation is nearly always through one of these houses, and there seems to be little or no effort to market the output cooperatively. The product is purchased on the citric-acid content by the large chemical supply houses in Germany, England, and the United States.

COST OF PRODUCTION OF BY-PRODUCTS.

The quantity of the by-products obtained from a given number of fresh lemons will depend upon the quality of the fruit, the season of the year, the time which has elapsed between the gathering and working up, and the efficiency of the latter process. When allowed to ripen upon the tree, the lemon loses a considerable part of its acidity and the oil is also less in quantity and of an inferior grade. Where the fruit is broken or bruised in handling, the yield of oil is diminished, and this is also the case where a number of days are allowed to elapse between picking and working up. The content of citric acid is not lessened by these faults, however. On the average quality of fruit, 100 pounds of oil and 675 pounds of citrate of lime, containing 430 pounds of citric acid, can be produced from 100,000 lemons. The average price for these substances varies from $80 to $100 for the oil and $75 to $95 for the citrate. At the time of writing, owing to the recent earthquake disaster in Sicily, the prices are firm and somewhat higher.

The cost of production is very difficult to estimate and will, of course, vary in every locality and almost with every factory. In the consular reports of the late Doctor Cheney he estimates the average value of lemons to the grower in Sicily at $150 per 100,000. The fruit going for by-products is the lowest grade, however, and will not average over $100 per 100,000, leaving a gross profit to the by-product producer of from $50 to $100. One sponge man can produce between 2 and 3 pounds of oil per day, for which he receives about 30 cents, making the cost of extracting the oil from 100,000 lemons from $10 to $15. Other processes about the factory are much cheaper, and it would seem, at the usual wages of workmen, that $5 to $10 additional would be a liberal estimate for other expenses, leaving a profit of from $30 to $70 jointly on 100 pounds of oil and a pipe of citrate of lime. It is believed that the above estimates are very conservative and that the actual profits are considerably higher than the figures given.

PLATES.

DESCRIPTION OF PLATES.

Plate I. Lemon groves on the Amalfi coast. Fig. 1.—Terraces of lemon trees on the mountain side near Majori. Masonry walls are built to keep the land from sliding. Fig. 2.—Terraces of lemon trees rising from the sea. The larger trees are olives. There is a trellis over each terrace for frost protection.

Plate II. An Italian and an American lemon grove compared. Fig. 1.—One of the better types of groves at Mascali, Sicily, showing the high-headed trees, a distributing furrow between the rows, and basins around the trees. Fig. 2.—A grove of low-headed trees in California.

Plate III. A lemon-picking scene and a packing-house interior. Fig. 1.—Picking and grading the fruit, Palermo. The lemons are being graded roughly for by-products and for export. Fig. 2.—Interior of a packing house at Catania, showing the padded bins used in grading and packing.

Plate IV. Preparation of citrate of lime. Fig. 1.—A crushing machine. Mills are not used for extracting lemon juice in Sicily. Fig. 2.—A lemon-juice press. This press acts also as a filter.

Plate V. Preparation of lemon oil. Fig. 1.—Paring lemons, 3-piece method, Palermo. This method is used only in the Palermo district and at Barcelona. Fig. 2.—Interior of lemon by-product factory, Syracuse. This shows one of the few factories in Italy using mechanical devices in handling the fruit.

Plate VI. Lemon-oil machinery. Fig. 1.—A lemon-oil machine used in Calabria. This machine is confined in its use to the Calabrian district, where it is also employed in the production of bergamot oil. Fig. 2.—Disks used in Calabrian machines. The surface of these disks is not unlike that of a burr mill.

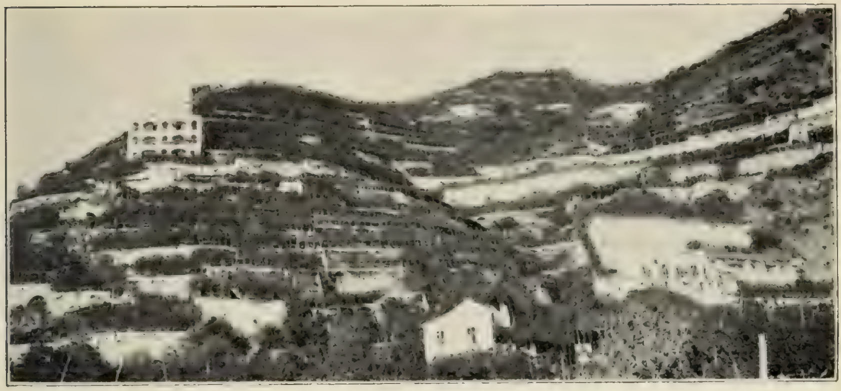

FIG. 1.—TERRACES ON THE MOUNTAIN SIDE.

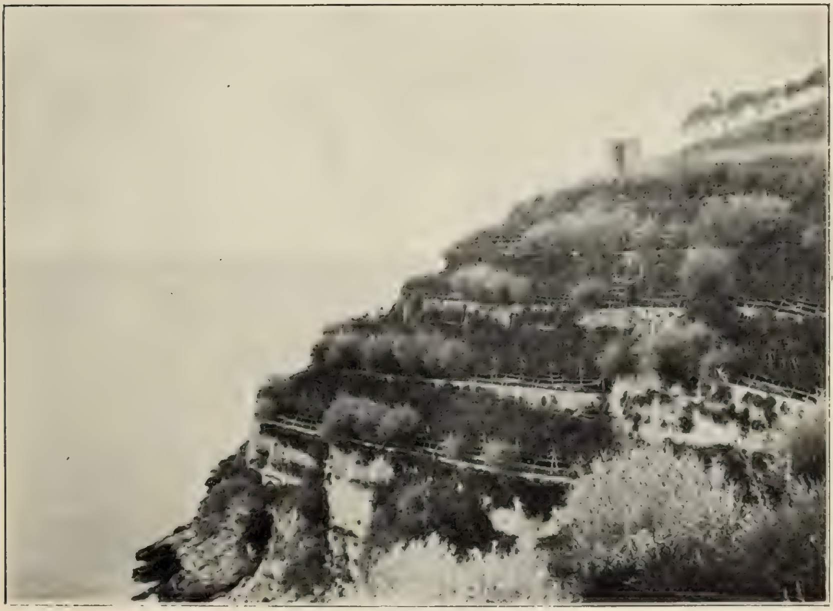

FIG. 2.—TERRACES RISING FROM THE SEA.

LEMON GROVES ON THE AMALFI COAST.

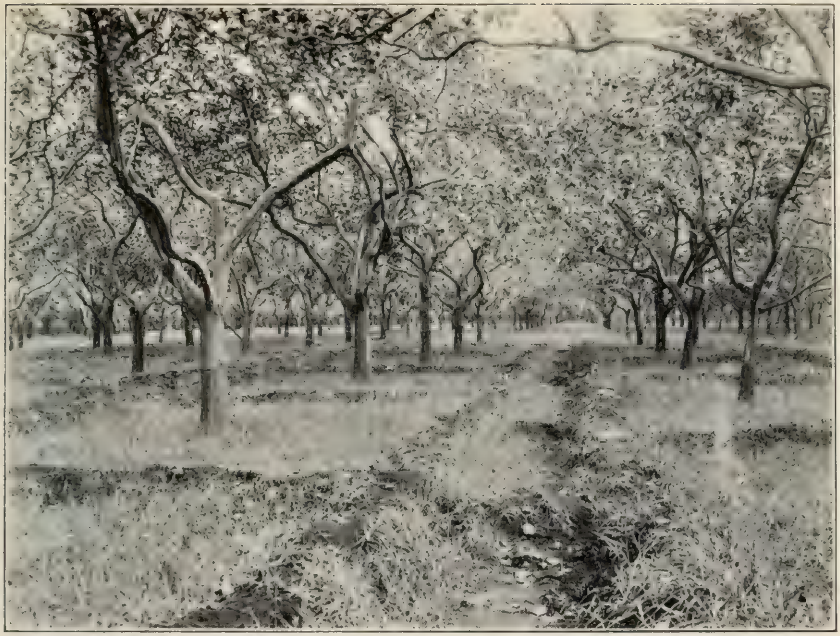

FIG. 1.—A GROVE AT MASCALI, SICILY, SHOWING A DISTRIBUTING FURROW AND BASINS AROUND THE TREES.

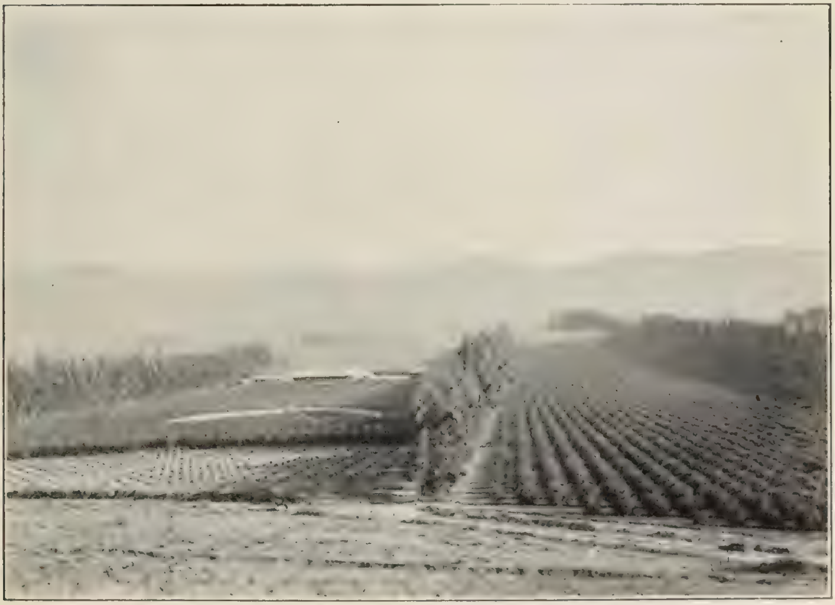

FIG. 2.—A GROVE OF LOW-HEADED TREES IN CALIFORNIA.

AN ITALIAN AND AN AMERICAN LEMON GROVE COMPARED.

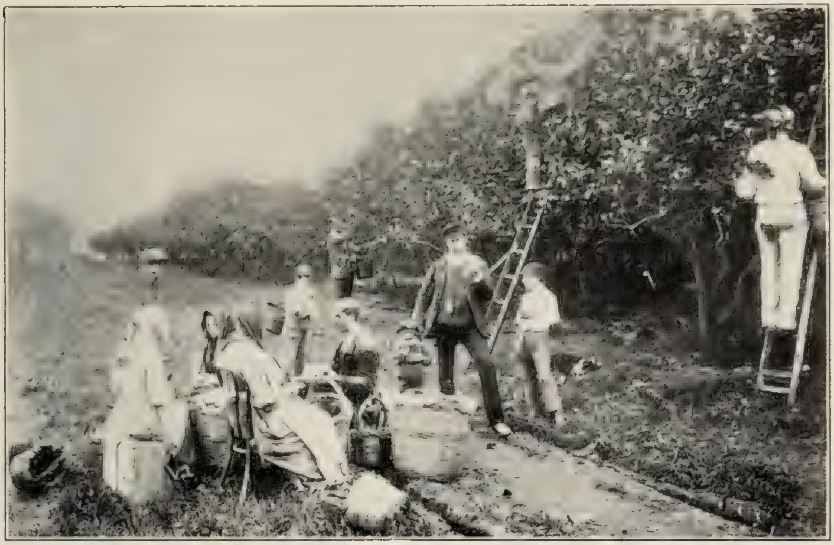

FIG. 1.—PICKING AND GRADING THE FRUIT, PALERMO.

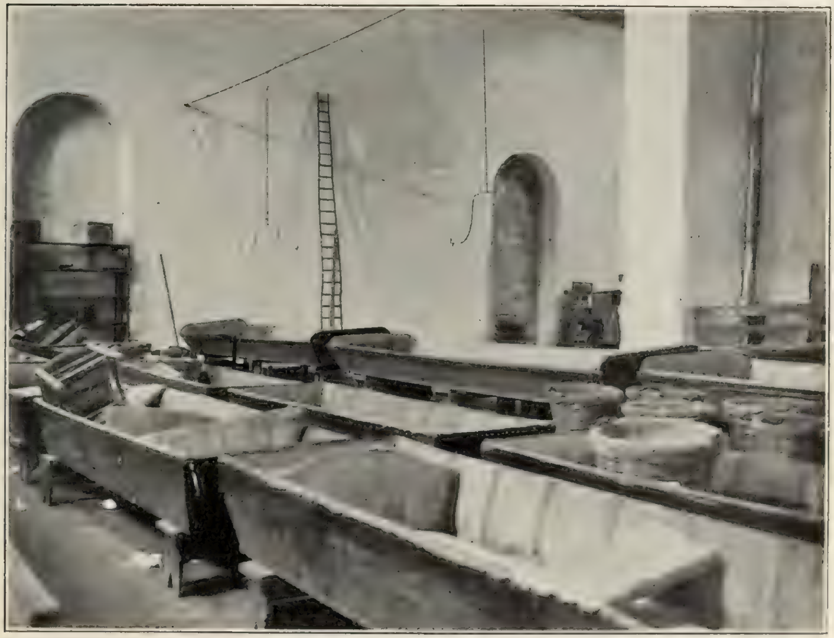

FIG. 2.—INTERIOR OF A PACKING HOUSE, CATANIA.

A LEMON-PICKING SCENE AND A PACKING-HOUSE INTERIOR.

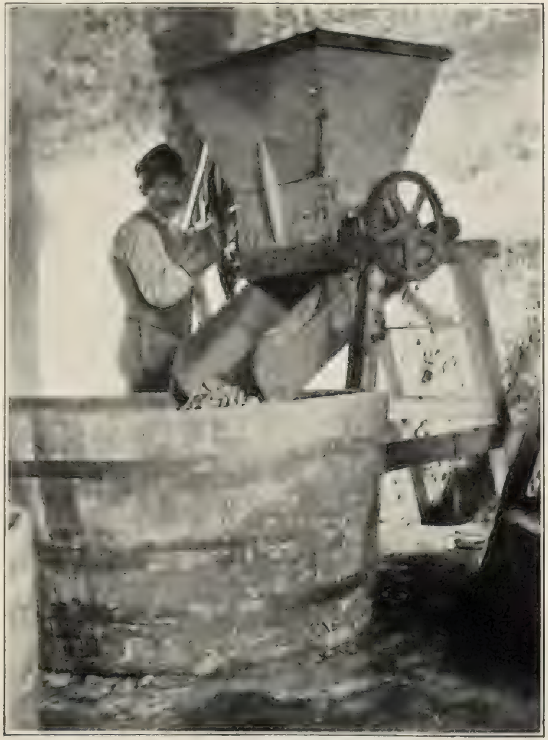

FIG. 1.—A CRUSHING MACHINE.

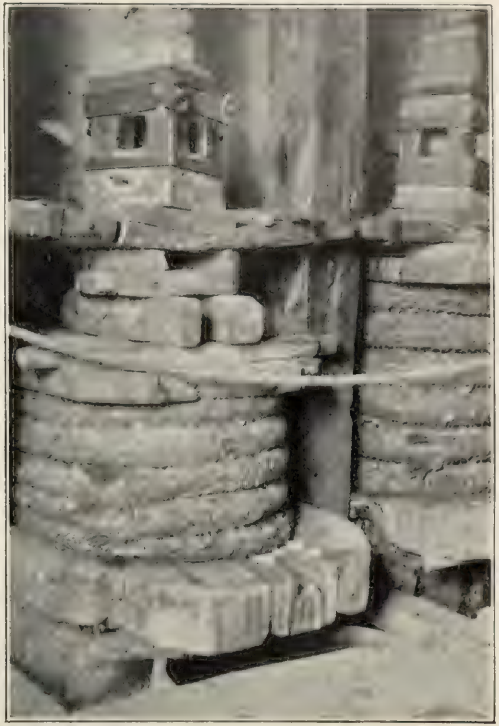

FIG. 2.—A LEMON-JUICE PRESS.

PREPARATION OF CITRATE OF LIME.

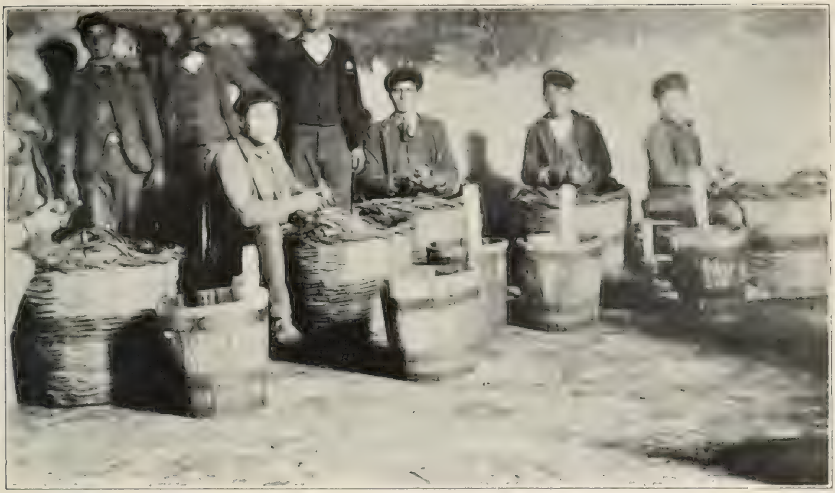

FIG. 1.—PARING LEMONS, 3-PIECE METHOD, PALERMO.

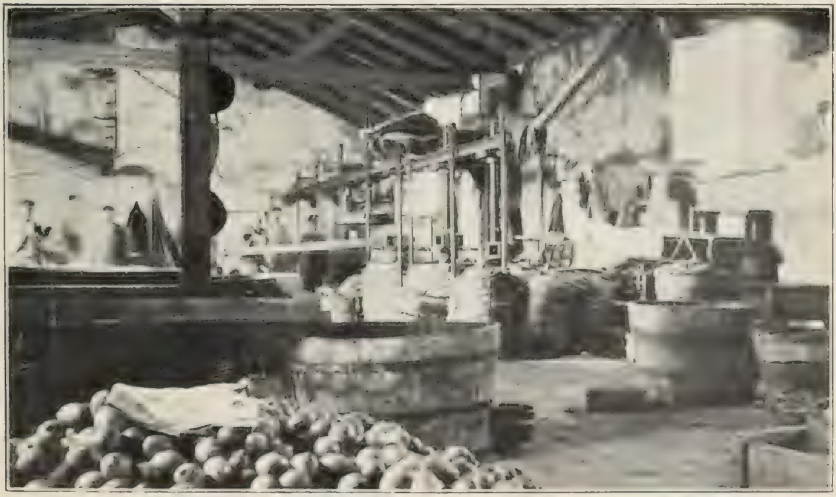

FIG. 2.—INTERIOR OF LEMON BY-PRODUCT FACTORY, SYRACUSE.

PREPARATION OF LEMON OIL.

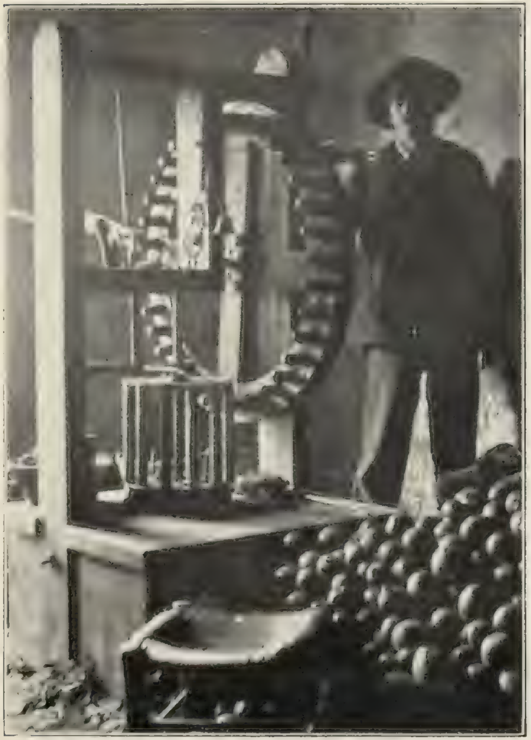

FIG. 1.—A LEMON-OIL MACHINE USED IN CALABRIA.

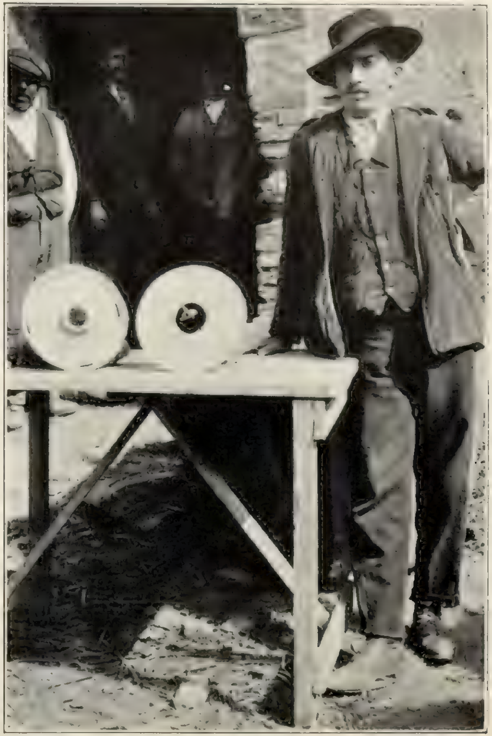

FIG. 2.—DISKS USED IN CALABRIAN MACHINES.

LEMON-OIL MACHINERY.

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